INDICES OF AQUATIC COMMUNITY INTEGRITY OF PERCHA AND TIERRA BLANCA CREEKS IN PERENNIAL SEGMENTS ADMINISTERED BY THE US BUREAU OF LAND MANAGEMENT, SIERRA COUNTY, NEW MEXICO

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Contract completion report
for
Contract # 01-5-28400

Submitted to
Western Division
U.S. Bureau of Land Management
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SUMMARY

Indices of aquatic community integrity were monitored during late spring, summer and early fall in 1995 at segments of Tierra Blanca and Percha creeks (Sierra County, NM) administered by the US Bureau of Land Management (BLM). Community integrity is defined here as the completeness of ecosystems functions expected of naturally intact communities. The studies were intended to establish bench marks of community integrity to compare between the two stream segments, to future studies at the same sites, and to results reported from other stream ecosystems. Primary intents of this study were to 1) estimate short-term variation (within warm seasons) associated with the various measures of community integrity, 2) determine the consistency with which indices indicated degree of integrity, 3) evaluate both anthropogenic and natural constraints to development of community integrity, and 4) assess the practicality and applicability of various measures to desert stream ecosystems. All specifications for BLM Contract 01-5-28400 were met during this study.

Indices to community integrity used in this study included measures of community metabolism, periphyton biomass, invertebrate diversity, invertebrate biotic integrity, and fish species richness and abundance. Community metabolism was estimated from measures of diurnal changes in oxygen concentration on three dates. Daylight generation of oxygen and night-time uptake rate of oxygen were measured to estimate gross primary production (P), community respiration (R), and P/R ratios. Periphyton biomass on both natural and artificial substrates was measured as dry weight and chlorophyll content. Benthic invertebrates were sampled with a Surber sampler on two dates at each site (6 samples each date and site) and enumerated by family and ecological function. The Shannon measure of diversity and the Hilsonhoff index to biotic integrity were calculated for macroinvertebrates. Fish density and diversity was estimated by electroshocking in three segments of Percha Creek, the only segment of the two to hold fish.

We also measured habitat factors suspected of naturally constraining the degree of community integrity developed at the two sites. Those habitat factors included stream and channel morphology, riparian cover, stream discharge, water temperature, nutrient chemistry, alkalinity, pH, oxygen concentration, conductivity, and bottom substrate structure. Both stream segments were mapped and major riparian species were recorded by area of stream surface they covered. Stream discharge was measured on several dates and locations within streams to determine flow rates entering and leaving each segment. Water chemistry was measured using a Hach field kit and results were compared to results from the Soil and Water Testing Laboratory at New Mexico State University. Oxygen, temperature and conductivity were measured with battery operated potentiometers. Bottom substrate size was categorized according to the Wentworth scale.

The indices of community integrity for the two stream segments were similar in most respects. Both segments were similarly enriched with high and apparently natural concentrations of orthophosphate phosphorus and nitrate nitrogen. Periphyton biomass reached higher amounts in Percha Creek, but varied greatly in part because of variation in stream discharge. Stream oxygen fluctuated moderately as a consequence of high rates of community metabolism, primary production, and community respiration, with net exports of organic matter from both segments indicated by P/R ratios of 1.3 to 1.4. Benthic macroinvertebrate diversity was low and the Hilsonhoff index of biotic integrity indicated "moderate organic loading" in both segments. Rio Grande suckers, *Catostomus plebeius*, and longfin dace, *Agosia chrysogaster*, occurred in the Percha Creek segment but not the Tierra Blanca segment.

Habitat and watershed characteristics also differed at the two stream segments, possibly explaining the few differences in community integrity. Mean valley width is narrower in the Percha Creek segment, resulting in greater substrate particle size, which caused more debris dams, larger pools, and greater diversity of flow velocity in Percha Creek. Mean flow velocity was greater in the Tierra Blanca Creek segment because stream channel slope (gradient) was greater. Although mean discharge into each stream segment was similar, location of springs serving each site differed in location, probably resulting in slightly higher temperature fluctuation and greater travertine ($CaCO_3$) precipitation in Tierra Blanca Creek. The travertine caused sediment concretion throughout much of the segment. The discharge per unit-area of watershed catchment was greater at Tierra Blanca, indicating a greater accumulation of groundwater than at Percha Creek and possibly greater flow stability within the study segments. Although a flash flood occurred at Percha Creek during the study, and not at Tierra Blanca, flow data are insufficient to conclude that flow in the Tierra Blanca watershed is in fact more stable.

Riparian tree cover, shade and input of allochthonous organic matter were greater at Tierra Blanca than at Percha Creek. More extensive margins of wetland plants (*Scirpus*, *Eleocharis*, *Juncus*, *Equisetum*) indicated "better" riparian condition at the Tierra Blanca segment. Differences in riparian condition along the two stream segments appeared to be related more to topographic and hydrologic differences than to adjacent land management practice. Information on past livestock use and impact on the two riparian sites is difficult to document, however. Although livestock were present in both areas during the study, there was no evidence of severe bank erosion caused by livestock. Greater variation in canyon constriction of flow in the Percha Creek segment appeared to cause more dramatic stream degradation in narrows and greater depth of sediment deposits where the bottom widened than in the Tierra Blanca segment. In Percha creek, this erosion and deposition dynamic created stream banks with little remaining wetland sediments or with fine sediment too steeply and deeply accumulated for roots of wetland plants to reach groundwater. Tierra Blanca had a wider valley bottom over

much of the segment and more uniform and widespread deposition of suitable wetland sediments. The flash flood at Percha Creek was probably of moderate severity based on U.S.Geological Survey (USGS) monitoring of past peak flows. However, it severely eroded wetland borders in the one area of Percha Creek where wetland plants were abundant, suggesting that differences in flow stability may also contribute to greater wetland development in Tierra Blanca Creek.

Higher and more consistent mean flow velocities may explain why mean periphyton biomass was lower at Tierra Blanca Creek, although unexplained statistical variation also contributes. Longfin dace are native to the Colorado River basin and were most likely introduced sometime before the 1960s. The Rio Grande Sucker appears to be native because it has been observed in several nearby streams, and it would be less likely to be introduced from Northern New Mexico where most populations now occur. The Rio Grande sucker may also exist in upper Tierra Blanca Creek where fish were recently observed, but not identified, by a BLM employee. The sucker may not exist in the Tierra Blanca segment because habitat is unsuitable for long-term sustenance, possibly due to low pool-riffle ratio and naturally concreted sediments. Rio Grande suckers may be an especially sensitive species of concern and Percha Creek may serve as protective refuge for sustaining genetic diversity.

Measures of community integrity based on standards developed for non-desert stream systems may misrepresent the extent that integrity has varied from desirable levels in Tierra Blanca and Percha creeks. Indices developed for wetter, cooler and less fertile watershed ecosystems with greater stream densities may misleadingly point to cultural impacts as the cause for conditions observed in both stream segments. Low invertebrate diversity, low fish diversity, and moderate indices of biotic integrity may be explained by the natural instability of runoff and productivity, isolation from similar stream habitats, and high summer temperatures associated with desert stream ecosystems. These factors probably combine to restrict community development to widespread and vagile forms with high tolerance to habitat variation and a few uniquely adapted taxa. However, understanding of desert-stream ecosystem integrity is rudimentary. Little is known about long-term dynamics in sites like Tierra Blanca and Percha creeks, except that some sustain unique species, such as certain fish species, in part because of their isolation and extreme habitat conditions. Many of those unique species may thrive under conditions of low diversity and moderate biotic integrity as measured by the Hilsonhoff index, suggesting that unique standards for ecosystem integrity are required. The role of riparian management decisions is less certain still with respect to influence on desert stream ecosystems.

We recommend that the BLM continue to investigate appropriate measures of aquatic community integrity by examining linkages between community dynamics in stream segments and the dynamics occurring at higher hierarchical levels in the Rio Grande watershed. Because factors defining local community integrity originate

within both the watershed and adjacent watersheds, we advocate an integrated approach to research and management that crosses watershed boundaries when appropriate. Long-term study is needed because controlling factors, such as extreme flash floods, droughts, and cumulative human impacts may operate over many years.

INTRODUCTION

This report documents a pilot study of stream-community integrity indices for segments of Percha and Tierra Blanca creeks (south central New Mexico) administered by the US Bureau of Land Management (BLM). A primary intent of this study was to identify low-cost indices to aquatic ecosystem integrity that may be useful measures of management effectiveness in sustaining various ecological outputs from ecosystem functions. This research focused on indices of aquatic habitat condition, nutrient availability, aquatic community metabolism, periphyton community biomass, invertebrate diversity, invertebrate biotic integrity, and fish biomass and productivity. This information provides a bench mark for future studies and management decisions. Two of the better uses for the data obtained from this study are determining the degree of ecosystem variation that occurs within and between study sites, and the intensity of sampling needed to make firm management decisions, once the desired statistical confidence is identified. The stream segments were sampled as generally specified in BLM contract 01-5-28400.

The studied stream segments are significant parts of isolated perennial reaches in intermittent stream channels. Spring sources occurred just above the two studied BLM administered stream segments and surface flow sank below the channel a short distance below the BLM administered stream segments. The watersheds of the two segments occur among several similar watersheds draining eastward toward the Rio Grande from the Black Range and its foothills in south-central New Mexico. Like many stream systems in arid environments, these sustain perennial flow at high elevations and become increasingly intermittent as they descend to drier elevations. Subsurface channel flow sometimes continues for significant distances down the channel from perennial flows at high elevation and reemerges as springs and seeps where subterranean features force groundwater to the surface. This water flows for variable distances before sinking once again into the channel substrate.

The stream systems draining the Black Range are steep, exposed to variable precipitation, and undergo intermittent flashy discharges superimposed over a more stable base flow discharge wherever perennial flow occurs. Extreme runoff events erode, mobilize and replace much of the channel sediment (Leopold et al. 1964) as flash flooding scours the reaches clean of algae and invertebrates (Fisher et al. 1982). In at least some perennial desert streams, algae and invertebrates recover to similar density and diversity within weeks (Fisher et al 1982; Meffe and Minckly 1987) through recolonization from similar undisturbed systems. Desert fish persist through extreme flooding (Meffe and Minckly 1987; Pearsons and Li 1992). Compared to streams in wetter biomes, however, little ecological understanding exists for desert stream systems; especially for desert streams composed of small and isolated perennial flows within intermittent and flashy stream ecosystems.

These lower-elevation perennial flows in the BLM managed segments compose small and isolated aquatic oases supporting aquatic communities widely separated by arid uplands and occasionally joined by exceptional runoff to perennial flow at higher and lower elevations. Groundwater adjacent to these isolated flows often supports significant riparian communities, which stand in stark contrast to the adjacent arid landscapes. These isolated communities are subsystems within larger ecosystems, formed by watershed process and cross-watershed process, including flight, human transport and other cross-watershed movement. The aquatic communities of the study segments are most likely to be connected to larger ecosystem process via certain transport mechanisms including flash flooding, introductions by humans, and aquatic insect flight. Dramatic changes in ecosystem character may occur with chance natural colonization or the intended introduction of a species. Some species may come and go causing a natural dynamic that is part of the ecosystem integrity. On the other hand, certain basic ecosystem outputs, such as total community respiration, may remain quite stable despite individual population changes.

Therefore the integrity assigned to an aquatic community depends greatly on the specificity of ecological outputs expected from the community. Focusing on single species measures of integrity will produce results different from a focus on species groups or whole-community processes. We examined a range of indices spanning the integration scale from whole community process (community metabolism), through important community groups (invertebrate families and functional groups) to important species (two fish species). In all cases we tried to consider how our observations were defined by larger-level ecosystem process, given the short time frame and small geographical scale of the study. To do this we compared our results with similar observations made for a variety of stream community conditions, including other arid environments, with the intent of defining what should be expected of a well-integrated aquatic community exposed to the environmental conditions observed at the two studied stream segments. We also discuss the limitations imposed by use of a single index or indices developed for conditions different from those occurring at the study sites.

With the limited funds available, we sought to research a range of indices to community integrity that could be measured relatively cheaply and yet provide the spectrum of information needed to make informed inferences. These indices included measures of taxonomic biodiversity, biotic integrity, primary production, community respiration, periphyton community biomass, and relative abundance of predators and other functional groups of consumers (Merritt and Cummins 1984) in the community. We also examined physical-chemical conditions that are known to regulate aquatic production, with emphasis on water quality, flow, overhead light, and substrate conditions.

The main management concern in the vicinity of the stream segments was appropriate intensity of livestock use in the riparian zone. Of the two segments, the

riparian zone along Tierra Blanca was perceived to be in better range condition. We therefore compared measures of aquatic community integrity at both stream segments to seek possible effects of grazing management and other causal mechanisms linked to riparian condition in the two watersheds.

METHODS AND MATERIALS

Study Site Location and Description

The BLM administered section of Percha Creek is a 1,230-m segment located in a third-order stream channel (USGS 7.5 minute maps). The stream segment is located three kilometers east of Hillsboro, off of highway 52, in Sierra County, NM. The coordinate position of the section is 32° 55' 00" N, 107° 31' 40" W. The BLM administered segment of Tierra Blanca Creek is located in a one square-mile (2.6 km^2) section containing a 2,213-m stream segment, which is in a second-order stream channel (USGS 7.5 minute maps). Tierra Blanca Creek is located about ten kilometers south of Hillsboro off of highway 27, also in Sierra County, New Mexico. The coordinate position of this section is 32° 50' 00" N, 107° 30' 45" W. Appendix G contains photocopies of both study segments from USGS 7.5 minute maps.

Both streams are classified as intermittent on USGS 7.5 minute maps. Stream segments above and below both reaches dry up except following rain storms and snow melt. Flow was continuous within the BLM reaches during the study, and is reported to be perennial within the experience of local residents and BLM managers. The total length of perennial flow is about 4-5 kilometers for both streams. Frequent storms were observed during July through September.

Peak discharge in Percha Creek, near Hillsboro, has been monitored by the USGS from 1957-1978, and from 1980 to present. The maximum recorded discharge at this station was 346 m^3/sec on 9/3/72, and less than 21 m^3 /sec in 1994. Maximum discharge over the last ten years has ranged from less than 21 to 167 m^3/sec, and exceeded 30 m^3/sec during three years (e.g. USGS 1994).

Habitat Characterization

Channel mapping

Stream channels were surveyed and mapped according to Platts et. al. (1983). Stream slopes, depths, and widths were measured using a surveying level, stadia rod, and compass. Transects were taken at each observed change in slope or stream direction, with a maximum distance between transects of 100 m. Depths were taken in the center of the stream, one quarter of the stream width to the left, and one quarter of the stream width to the right. Stream length was measured along the thalweg using a measuring tape or hip chain. Mean surface area, volume, depth, and width were calculated by using weighted averages of transect values. We surveyed Percha Creek on 4/30/95 and Tierra Blanca Creek on 6/7/95, when both streams were near base flow.

Maps (USGS 7.5 minute) were used to find watershed area, mean channel slope above BLM reaches, stream segment distance from the Rio Grande, and physical barriers within each stream.

Habitat

Stream length and location of each pool, riffle, and run were recorded to the nearest meter. Embeddedness, stream bank stability, soil alteration, vegetative stability, and vegetative cover were characterized according to Platts et. al. (1983) for each pool, riffle, or run. Overhead vegetational cover was estimated by species, every sixty meters, using a densiometer.

Stream discharge

Mean stream velocity was measured with a pygmy current meter and multiplied by stream cross-sectional area to determine discharge (Orth 1983). Discharge was estimated at Percha Creek on 7/12/95, 8/17/95, and 10/14/95, and at Tierra Blanca Creek on 7/18/95, 7/21/95, and 10/7/95 (Table 1). At Percha Creek discharge was estimated near the middle of the reach, just below the entry point of a spring-fed tributary (stream distance 450 m), and at the upper end of the reach (stream distance 1,230 m). Spring discharge was measured by timing funneled flow into a 1-liter plastic bottle. At Tierra Blanca Creek discharge was measured at the upper end (stream distance 2,013 m), middle (1,197 m), and lower end (0 m) of the reach.

Water Chemistry

Water samples were collected on each site visit, and opportunistically after storms on 8/17/95 at Percha Creek, and on 7/18/95 and 7/21/95 at Tierra Blanca Creek (Table 1). Samples were collected in 250-ml, acid washed, neoprene containers, and tested or frozen immediately upon return to the laboratory. Nitrate nitrogen, reactive orthophosphate, sulfate, alkalinity, and turbidity were measured with a Hach DREL/1C portable colorimeter. Conductivity was measured with a YSI model 33 S-C-T meter, and pH with a Beckman 34 pH meter. All of the above measurements were made on site at Percha Creek on 7/12/95, 8/17/95, and 10/14/95, and at Tierra Blanca Creek on 7/18/95, 8/21/95, and 10/7/95 (Table 1).

We sent samples from Percha Creek on 9/22/95 and Tierra Blanca Creek on 10/7/95 to the New Mexico State University (NMSU) Soil and Water Testing Laboratory, where they were tested for alkalinity, chloride, conductivity, pH, total phosphorus, orthophosphate phosphorus, nitrate nitrogen, sulfate, cadmium, copper, lead, mercury, nickel, and selenium.

Table 1. Dates for all parameters sampled in 1995 at Percha Creek and Tierra Blanca Creek.

	Date sampled	Discharge/location	Water chemistry	Diurnal Dissolved Oxygen and Temperature	Natural periphyton growth	Periphyton Artificial substrate		Invertebrates	Fish
						# of plates	Days in stream		
Percha Creek	4/30/95		X	X					
	6/8/95		X						X
	6/15/95					2	7		
	6/19/95					3	11		
	6/21/95								X
	7/12/95	lower[a] and upper[b]	X	X				X	
	8/17/95	lower and upper	X	X	X				
	9/2/95		X		X				
	9/22/95		X			6[g]	23	X	
	10/14/95	lower and upper	X	X	X				
Percha Creek springs	8/17/95	#1 and #2[c]	X						
	9/2/95	#1, #2, and #3	X						
	9/22/95								
	10/14/95	#1, #2, and #3	X						
Tierra Blanca Creek	4/30/95		X	X					
	6/7/95		X						
	6/15/95					1, 3	6, 41		
	6/19/95							X	
	7/18/95	middle[d]	X	X	X	4	29		
	8/21/95	lower[e], middle, upper[f]	X	X	X				
	10/7/95	lower, middle, upper	X	X	X			X	

[a] 1,230 m stream distance (see Figure 1)
[b] 450 m stream distance (see Figure 1)
[c] see Figure 1 for spring locations
[d] 1,197 m stream distance (see Figure 1)
[e] 0 m stream distance (see Figure 1)
[f] 2,013 m stream distance (see Figure 1)
[g] three plates in a lighted area and three plates in an adjacent shaded area

Diurnal Dissolved Oxygen and Temperature Profiles

Dissolved oxygen and water temperature were measured with a YSI model 57 oxygen meter on 4/30/95 before dawn, at mid-day, afternoon, and late afternoon, at each site to compare stream productivity. More complete oxygen profiles were taken at Percha Creek on 7/12/95, 8/17/95, and 10/7/95, and at Tierra Blanca Creek on 7/18/95, 7/21/95, and 10/7/95 (Table 1). Water temperature and dissolved oxygen were measured hourly from 6:00 am until about two hours after dark. Daily productivity and community respiration rate were approximated from the diel oxygen patterns according to Cole (1983) and Odum (1956). Variation in dissolved oxygen concentration was caused by daytime photosynthetic release of oxygen in excess of respiration, and by night-time community respiration, which removed oxygen without photosynthetic replacement. The extent of fluctuation also depends on turbulent mixing, which influences diffusion of oxygen across the air-water interface. No attempt was made to correct for diffusion. Because the mean depth, slope, and velocity were generally similar in the two streams, the variation in oxygen was assumed to accurately indicate relative primary production in both streams.

Periphyton on Natural Substrate

Substrate was sampled in open unshaded areas within each reach to determine periphyton biomass on different stream substrate sizes. Substrates were collected from Percha Creek on 8/7/95 and 9/2/95, and from Tierra Blanca Creek on 7/19/95 and 8/21/95. Substrate samples also were collected at Percha Creek on 10/14/95 and at Tierra Blanca Creek on 10/7/95 from shaded areas and adjacent unshaded areas (Table 1). Substrates collected from 0.30 m^2 areas were placed in plastic sealable bags and frozen immediately upon return to the laboratory. Samples were thawed between 24 hours and seven days later. Chlorophyll was extracted with 90% acetone and analyzed with a Sargent-Welch 6-550 UV/VIS spectrophotometer as described by Franson et. al. (1985). Mean particle size was determined using the weighted mean volume of each particle size category in a sample. Large particles were submerged individually in water to estimate the displaced volume. Smaller particles were sieved through U.S. standard testing sieves and volume was estimated from the residual on each sieve. Regression analysis of substrate particle diameter versus chlorophyll a concentration was performed to examine the relationship between substrate size and periphyton growth.

Periphyton on Artificial Substrate

Plexiglas plates were used to estimate the accumulation rate of periphyton. The plates had a roughened upper surface of 64 cm^2. The plates were attached to flattened stakes or plywood with screws, and placed on the bottom of the creek in open, well lit areas. Plates were placed in Percha Creek on 6/8/95 and removed on 6/15/95 and 6/19/95. Plates were placed in Tierra Blanca Creek on 6/7/95 but additional plates were added on 6/19/95 to replace a set that was lost. Because there was no periphyton accumulation on the remaining plates that were checked on 6/19/95, all plates were collected from Tierra Blanca on 7/18/95 (Table 1). Individual plates were unscrewed during later site visits, placed in plastic sealable bags and frozen upon return to the laboratory. Periphyton was removed from the plates with a razor blade, placed in acetone for 24 hours, and analyzed for chlorophyll concentration with a Sargent-Welch 6-550 UV/VIS spectrophotometer according to Franson et al. (1985). After extraction, the acetone was recombined with the solid portion, dried for 24 hours in a drying oven and weighed to determine dry-weight biomass.

To compare growth in lighted versus shaded areas, one set of plates was placed in an open, well lit area and one set in an adjacent shaded area. These plates were placed at Percha Creek on 9/22/95 and collected on 10/14/95. Tierra Blanca Creek was inaccessible at this time.

Invertebrate Sampling

Macro-invertebrates were collected with a 0.093 m^2 area Serber sampler with 1-mm mesh opening. Six samples were collected from each site. Sample sites were chosen by dividing each reach into six equal parts, beginning at a random point. The dominant substrate at each sample site was recorded. Percha Creek was sampled on 7/12/95 and 9/22/95. Tierra Blanca Creek was sampled on 6/19/95 and 10/7/95 (Table 1). Invertebrates were placed in neoprene bottles and fixed in 95% ethanol. Samples were mailed to the BLM Aquatic Ecosystem Laboratory in Logan, Utah for counting, identification, assignment to functional groups and calculation of diversity and biotic integrity indices.

Fish Sampling

Fish occurred only in the Percha Creek segment. Three reaches of Percha Creek were electrofished to estimate fish abundance using a Smith and Root battery powered backpack electroshocker. Representative reaches were selected in the upper, middle, and lower parts of the segment. Each reach contained at least one pool and one riffle. The reach lengths were 50 m for the first, 40 m for the second, and 30 m for the third reach. Each reach was isolated with block nets before

sampling. Three to four passes of each reach were made with constant effort (Platts et al. 1984) and the number of fish caught on each pass was recorded by species. Lengths and weights were measured for up to 50 fish of each species caught during the first pass, and up to 25 lengths were measured for each species caught in the following passes. Any remaining fish were counted and returned to the stream outside of the blocked reach. Measured fish were assumed to be a random sample of the total fish caught.

For each species, length-weight relationships were calculated by regression analysis of the natural log of length versus the natural log of weight. This relationship was used to estimate the weight of each fish measured, and to estimate total abundance by the Zippin method (Ricker, 1975). Productivity was estimated as the mean weight increment between year classes. Ratios of productivity to biomass were calculated as the natural log of the weight increment (Ricker 1975). All analyses of variance are expressed as standard error of the mean. The coefficient of delineation, R^2, was the measure of variance used for regression equations. Statistical significance was based on a probability of 0.05. Statistics were estimated using the statistical software package Systat.

RESULTS

Habitat

Stream morphology

Stream channel distance from the Percha Creek study segment to the Rio Grande is 25.3 km. Based on map analysis, there are no obvious barriers to fish migration caused by waterfalls or dams when there is continuous flow, which is uncommon for extended periods. Five springs occur near Percha Creek, four of which discharge into the creek (Figure 1). Stream channel cross sections, shown in Figure 1, reveal diverse morphology dominated by narrow riffles and runs in the upper reach, large pools in the middle reach, and wide riffles in the lower reach. Much of the upper section is a narrow canyon with large boulders in and around the stream. The stream meanders relatively little through the reach. Complete stream mapping transects are provided in Appendix A.

Stream channel distance from the Tierra Blanca Creek study segment to the Rio Grande is 24.1 km, also with no falls or other obvious barriers to fish migration (as indicated by USGS maps) during uncommon periods of continuous flow. No discrete springs occur near the BLM administered segment of Tierra Blanca Creek. The segment meanders more than at Percha Creek and contains more extended runs without pools (Figure 2). As the stream runs through a narrow box canyon near the lower end of the segment, the habitat becomes primarily riffle. Complete stream mapping transect data are also provided in Appendix A.

In the watershed above the two segments, Percha Creek has greater channel slope (gradient), as shown in Table 2, and greater area (218 km^2 versus 95 km^2). As a consequence, Percha Creek has greater mean width and depth than Tierra Blanca Creek. Total mean volume and surface area are lower at Percha Creek, however, because the total segment length is less. Within BLM segments, the Tierra Blanca channel has greater mean slope and less variation in slope than does the Percha Creek channel (Figure 3).

Stream Habitat and Riparian Condition

The Percha Creek segment had a greater pool/riffle ratio than the Tierra Blanca Creek segment, and much larger pools occurred in Percha Creek. The bottom substrate particle size in Percha Creek was bimodally distributed between rubble and very fine sediment. Gravel made up the smallest fraction. In contrast, gravel dominated at Tierra Blanca Creek, and fine sediments were scarce. Whereas 40% of Percha Creek was more than 25% embedded, 60% of Tierra Blanca Creek was more than 25% embedded. Substrate concretion was common throughout the

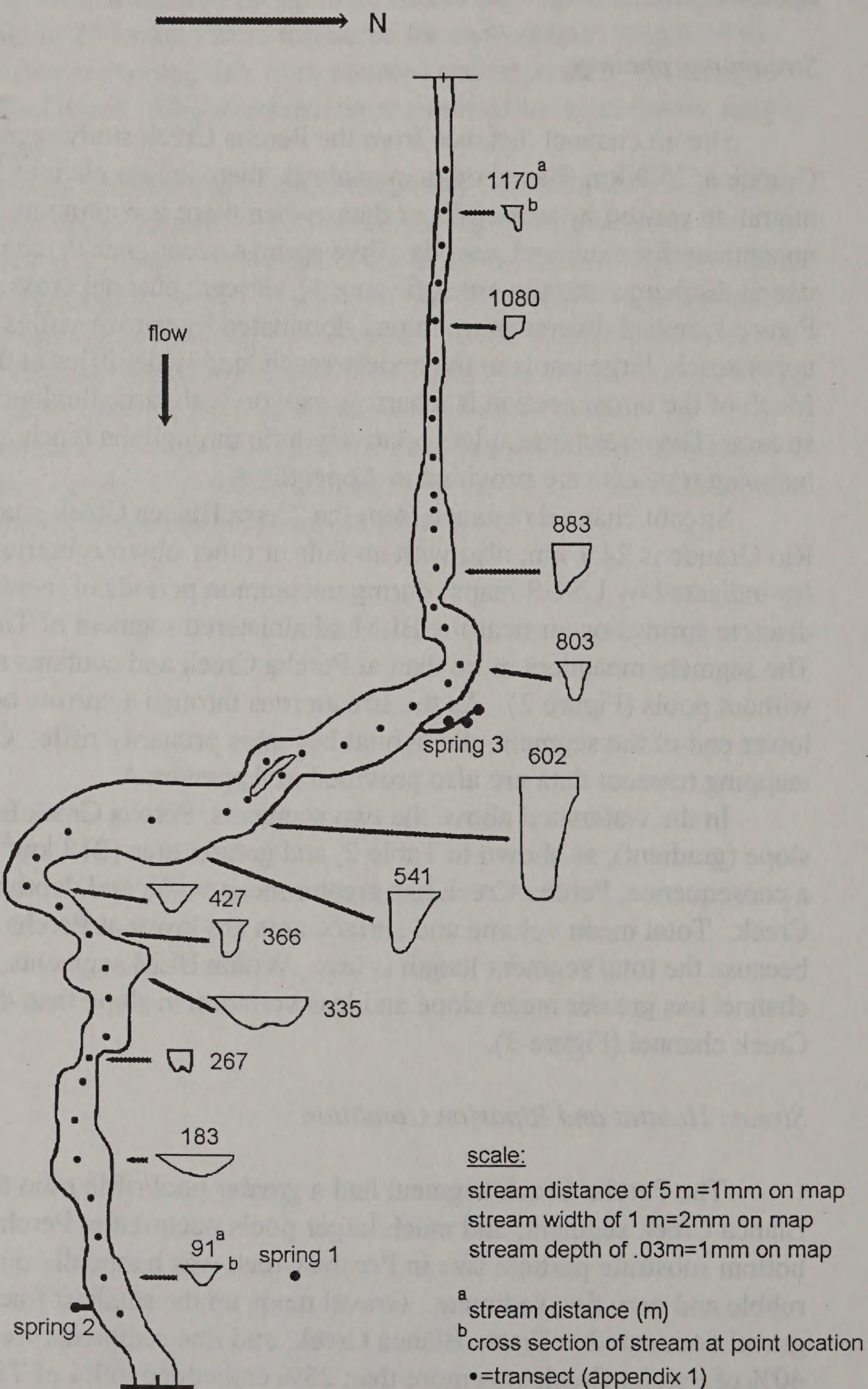


Figure 1. Stream diagram with cross sections, Percha Creek, New Mexico, 4/30/95.

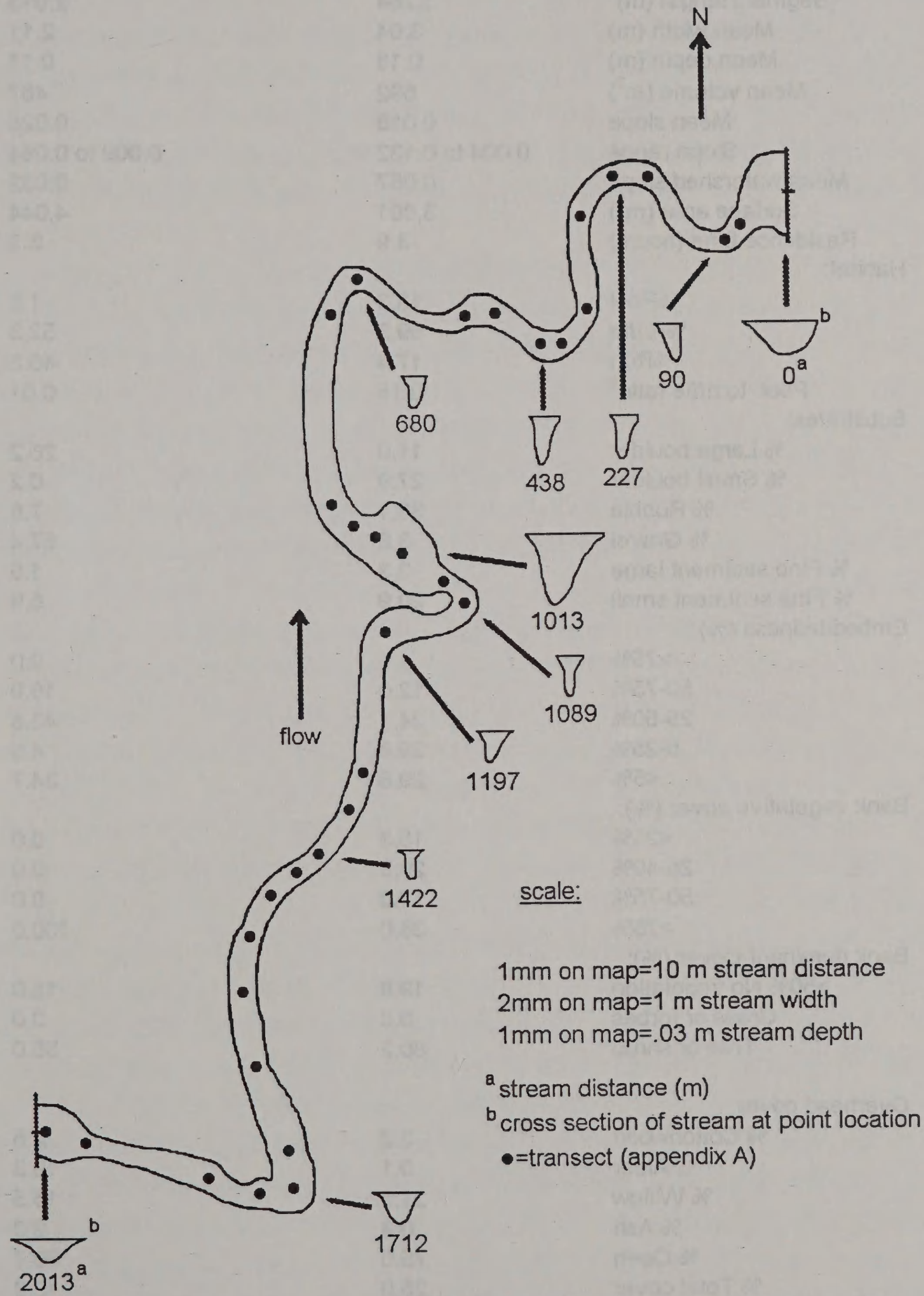


Figure 2. Stream diagram with cross sections, Tierra Blanca Creek, New Mexico, 6/7/95.

Table 2. Stream morphology and Habitat comparison of Percha and Tierra Blanca Creeks.

	Percha Creek	Tierra Blanca Creek
Morphology:		
Segment length (m)[a]	1,264	2,013
Mean width (m)	3.04	2.11
Mean depth (m)	0.18	0.11
Mean volume (m^3)	692	467
Mean slope	0.018	0.025
Slope range	0.004 to 0.132	0.009 to 0.084
Mean watershed slope	0.057	0.032
Surface area (m^2)	3,801	4,044
Residence time (hours)	3.9	3.3
Habitat:		
%Pool	13.3	1.3
%Riffle	69.3	52.3
%Run	17.4	46.3
Pool to riffle ratio[b]	0.15	0.01
Substrates:		
% Large boulder	11.0	26.2
% Small boulder	27.9	0.2
% Rubble	33.1	7.8
% Gravel	3.8	57.4
% Fine sediment large	3.3	1.5
% Fine sediment small	20.9	6.9
Embeddedness (%):		
>75%	4.4	0.0
50-75%	12.0	16.9
25-50%	24.1	43.8
5-25%	29.8	4.6
<5%	29.6	34.7
Bank vegetative cover (%):		
<25%	15.3	0.0
25-49%	29.8	0.0
50-75%	17.0	0.0
>75%	38.0	100.0
Bank dominant Cover (%):		
>50% No vegetation	19.8	15.0
Grass or forbes	0.0	0.0
Tree or shrub	80.2	85.0
Overhead cover		
% Cottonwood	3.2	2.5
% Alder	0.1	19.3
% Willow	21.3	15.5
% Ash	0.4	2.0
% Open	75.0	60.7
% Total cover	25.0	40.3

[a] Within BLM areas. Percha Creek stream distance includes split channel.

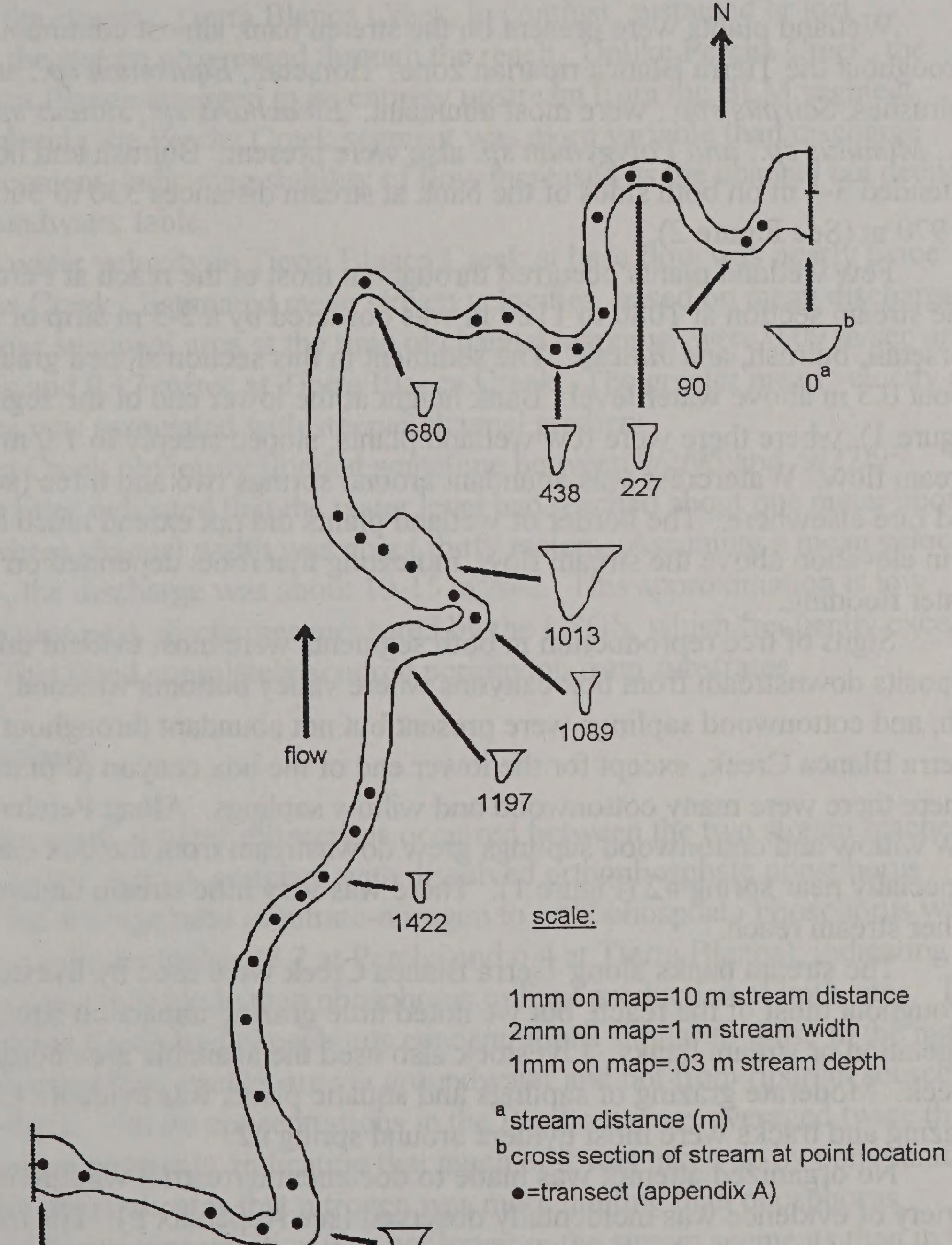


Figure 2. Stream diagram with cross sections, Tierra Blanca Creek, New Mexico, 6/7/95.

reach at Tierra Blanca Creek, probably from calcium carbonate precipitation. No such concretion was observed at Percha Creek.

Percha Creek has a greater proportion of exposed soil and smaller percentage of tree cover along the stream bank (Table 2). Tierra Blanca Creek has 40.3% overhead cover, predominantly Alder and Willow. Percha Creek had only 25% overhead cover, predominantly Willow.

Wetland plants were present on the stream bank almost continuously throughout the Tierra Blanca riparian zone. Horsetail, *Equisetum sp.*, and bulrushes, *Scirpus spp.*, were most abundant. *Eleocharis sp.*, *Juncus sp.*, *Rorripa sp.*, *Mimulus sp.*, *and Polygynum sp.* also were present. Bulrush and horsetail extended 3-4 m on both sides of the bank at stream distances 330 to 360 m and 940 to 970 m (See Figure 2).

Few wetland plants occurred throughout most of the reach at Percha Creek. The stream section at 1080 to 1120 m was bordered by a 2-3 m strip of *Eleocharis*, horsetail, bulrush, and *Juncus*. The sediment in this section sloped gradually to about 0.3 m above water level. Bank height at the lower end of the segment (0 m on Figure 1), where there were few wetland plants, sloped steeply to 1.0 m above the stream flow. Watercress was abundant around springs two and three (see Figure 1) and rare elsewhere. The border of wetland plants did not extend much beyond 0.3 m in elevation above the stream flow, indicating that roots depended on ground water flooding.

Signs of tree reproduction in both segments were most evident on sandy deposits downstream from box canyons where valley bottoms widened. Willow, ash, and cottonwood saplings were present but not abundant throughout the reach at Tierra Blanca Creek, except for the lower end of the box canyon (0 m in figure 2), where there were many cottonwood and willow saplings. Along Percha Creek, a few willow and cottonwood saplings grew downstream from the box canyon, especially near spring #2 (Figure 1). There was very little stream undercutting in either stream reach.

The stream banks along Tierra Blanca Creek were used by livestock throughout most of the reach, but we noted little grazing impact on stream vegetation or stream banks. Livestock also used the available area bordering Percha Creek. Moderate grazing of saplings and aquatic plants was evident. Livestock grazing and tracks were most evident around spring #2.

No organized attempt was made to document terrestrial wildlife use but a variety of evidence was incidentally observed (see Appendix F). The most common semi-aquatic species observed in both segments were blacknecked garter snakes and canyon tree frogs (adults and tadpoles). No sensitive species were observed.

Stream discharge

Discharge in Percha and Tierra Blanca Creeks were similar (Table 3) even though Percha watershed was more than twice as large. Spring flows into Percha Creek were small compared to the estimated discharge accrual within the stream channel, indicating that most of the discharge accumulated through bottom seepage directly into the stream. Tierra Blanca Creek, in contrast, sustained or lost discharge as the stream progressed through the reach. Unlike Percha Creek, the water in Tierra Blanca emerged in its entirety upstream from the BLM segment. Discharge entering the Percha Creek segment was more variable than discharge leaving the segment, indicating stability of flow increased as the channel cut deeper into the groundwater table.

Mean water velocity in Tierra Blanca Creek at base flow was nearly twice that in Percha Creek. Estimated mean stream velocities, based on mean discharge and mean cross sectional area at the time of channel mapping, were 0.09 m/sec at Percha Creek and 0.17 m/sec at Tierra Blanca Creek. The greater mean velocity at Tierra Blanca was associated with steeper channel gradient.

Percha Creek obviously flooded sometime between 9/2/95 and 9/22/95. Stream bank litter indicated that the water level had reached about one meter above base flow, where channel width was about thirty meters. Assuming a mean velocity of 0.5 m/sec, the discharge was about 10-15 m^3/sec. This approximation is low compared to past peak discharges measured by the USGS, which frequently exceed 21 m^3/sec. This flood completely scoured periphyton from substrates.

Water Chemistry

No consistent nutrient differences occurred between the two stream reaches. Both reaches were equally enriched with dissolved orthophosphate phosphorus (Table 4). The average ratio of nitrate-nitrogen to orthophosphate phosphorus was relatively low in both reaches (8.7 at Percha and 6.4 at Tierra Blanca), indicating that nitrogen was more likely than phosphorus to limit production at both sites. The springs at Percha Creek had phosphorus concentrations similar to those in the main channel, indicating that sources are via groundwater and not from riparian sources such as livestock. Nitrate concentrations in the Percha springs averaged twice that in the two stream segments, indicating that much of it was taken up by community process. This also indicates that nitrogen was more limiting than phosphorus, because phosphorus concentration was not lower in the stream segments than in the springs.

Storms generally elevated orthophosphate phosphorus concentrations in the streams and diluted nitrate nitrogen, except on 8/21/95, when both phosphate and nitrogen were diluted. Storms diluted total dissolved solids. These results indicate

Table 3. Stream discharge from Tierra Blanca and Percha Creeks and associated springs.

Date	Percha Springs[a] #2	Percha Springs[a] #3	Percha Creek Upper[b]	Percha Creek Lower[c]	Tierra Blanca Creek Upper[d]	Tierra Blanca Creek Middle[e]	Tierra Blanca Creek Lower[f]
	Discharge (liters/sec)						
7/12/95			8	54			
7/18/95						50	
7/21/95					50	46	34
8/17/95	0.3	1	13	42			
10/7/95					30	26	30
10/14/95	0.3	3	23	51			
Mean	0.3		14.7	49.0	40.0	36.0	32.0
Segment mean			31.8 ± 8.1		38.0 ± 3.9		

[a] See Figure 1, [b] 1230 m stream distance, [c] 450 m, [d] 1197 m, [e] 2013 m, [f] 0 m

Table 4. Water quality data for BLM reaches of Percha and Tierra Blanca Creeks.

Creek	Date	PO_4-P (mg/l)	NO_3-N (mg/l)	SO^{4+} (mg/l)	Turbidity (ftu)	pH	Conductivity (umhos)	Alkalinity (mg/l $CaCO_3$)	TDS (mg/l)
Percha	4/30/95	0.07	0.25	49		7.01	370	139	210
Percha	6/8/95	0.08	0.05	70	.	7.42	440	106	250
Percha	7/12/95	0.13	1.00	80	.	7.51	370	157	210
Percha	8/17/95	0.03	1.50	70	5	7.71	550		.
Percha	9/2/95	0.01	0.25	55		7.76	370	182	210
Percha	9/22/95	0.02	0.10	67	.	7.89	420	219	150
Percha	10/14/95	0.07	0.50	65	0	7.80	480	211	230
Percha mean		0.06 ±0.02	0.52 ±0.20	65 ±4		7.59 ±0.11	429 ±26	169 ±18	210 ±14
Percha Spring 1	8/17/95	0..07	0.00	60	30	.	.	.	.
Percha Spring 1	9/2/95	0.05	1.30	65	.	7.68	469	172	260
Percha Spring 1	10/14/95	0.08	2.50	65	0	7.09	510	198	280
Percha Spring 2	8/17/95	0.07	1.00	65	0	7.20	.	.	.
Percha Spring 2	9/2/95	0.02	1.10	67	.	7.58	370	146	190
Percha Spring 2	10/14/95	0.08	1.20	65	0	7.13	500	207	310
Percha Spring 3	8/17/95	0.03	1.25	70	0	7.10	.	.	.
Percha Spring 3	9/2/95	0.08	0.20	58	.	7.46	450	196	310
Percha Spring 3	10/14/95	0.05	0.25	65	0	7.86	490	248	320
Percha Spring mean		0.06 ±0.01	0.98 ±0.25	64 ±1		7.39 ±0.11	465 ±21	195 ±14	278 ±20
Percha storm	8/17/95	0.12	0.25	75	.	7.94	430	159	270
Tierra Blanca	4/30/95	0.07	0.25	49	.	7.01	370	139	210
Tierra Blanca	6/7/95	0.03	1.50	43		7.09	460	92	260
Tierra Blanca	7/18/95	0..03	0.00	70	5	8.18		.	.
Tierra Blanca	8/21/95	0.14	0.25	50	1	8.01	410	148	150
Tierra Blanca	10/7/95	0.07	0.25	65	0	7.83	355	194	210
Tierra Blanca mean		0.07 ±0.02	0.45 ±0.27	55 ±5	2 ±2	7.62 ±0.24	399 ±23	143 ±21	208 ±23
Tierra pool [a]	8/21/95	0.13	1.75	75		7.49	700	138	180
Tierra pool [a]	10/7/95	0.00	1.30	100	0.5	7.60	575	294	350
Tierra storm	7/18/95	0.13	0.00	70	9	8.17	430	173	170
Tierra storm	8/21/95	0.07	0.00	55		7.69	405	115	150
Tierra Blanca storm mean		0.10 ±.03	0.00 ±0.00	63±8	.	7.93 ±0.24	418 ±13	144 ±29	160 ±10

[a] large isolated pool at bottom of canyon, 0 m.

that little dissolved solids and nitrate are added to the stream from overland storm flow but dissolved phosphate is significantly increased. The two streams and the springs also have similar pH, alkalinity, conductivity, and total dissolved solids. At the observed pH, the alkalinity is 100% bicarbonate alkalinity with substantial capacity for buffering against diurnal pH changes.

The NMSU Soil and Water Testing Laboratory results were generally in agreement with the results obtained using the Hach kit (Table 5). The somewhat lower pH and alkalinity values and higher conductivity values estimated in the laboratory may be a result of delay between thawing the water samples and completing these tests. The laboratory values obtained for orthophosphate-phosphorus were lower than the values obtained with the Hach kit. Heavy metal concentrations were low in both creeks; Copper was the only metal detectable at the limits defined in the analyses.

Diurnal Dissolved Oxygen, primary productivity, and Temperature

Dissolved oxygen ranged from 5.4 mg/liter to 9.5 mg/liter at Percha Creek, (Figure 4) and from 6.5 mg/liter to 11.0 mg/liter at Tierra Blanca Creek. The dissolved oxygen in both streams remained above 61% saturation and reached supersaturation up to 124% on certain days. The variation in saturation percentage indicated relatively intense community metabolism with both high primary production and community respiration. This was consistent with high nutrient concentrations in both streams. Photosynthesis generates oxygen in excess of saturation while respiration removes oxygen. The diurnal flux observed in Figure 4 reflects the relative intensity of photosynthesis and community respiration.

Assuming that difference in stream gas exchanges with the atmosphere were small, Percha Creek appeared to have greater primary productivity than Tierra Blanca Creek on 4/30/95 and during the summer, and similar primary productivity in October (Table 6). However high variation and error due to diffusion in gas exchange preclude concluding that they are in fact higher. Gas exchange due to diffusion would underestimate primary productivity in Tierra Blanca Creek more than in Percha Creek because gas exchange is a function of velocity, which is greater in Tierra Blanca Creek. Therefore we cannot certainly conclude that production was lower at Tierra Blanca Creek based on these data. Whereas Percha Creek averaged 2,880 mg/m^2/day O_2 respiration, Tierra Blanca averaged 2,288 mg/m^2/day O_2. Community primary productivity averaged 4,056 mg/m^2/day O_2, at Percha Creek and 2,988 mg/m^2/day O_2 at Tierra Blanca Creek.

The ratios of photosynthesis to respiration (P/R) indicate that both segments produced more than was respired; therefore both streams exported organic matter to downstream locations. This also indicates that the stream segments were not exposed to significant organic loads from upstream, either from natural or pollution

Table 5. NMSU Soil and Water Testing Laboratory results for Percha Creek on 9/22/95, and Tierra Blanca Creek on 10/7/95.

Analysis	Percha Creek 9/22/95		Tierra Blanca Creek 10/7/95	
	Laboratory results	Hach kit results	Laboratory results	Hach kit results
Nitrate/nitrite as N (mg/l)	0.61	0.10	less than 0.05	0.25
Water Kjeldahl Nitrogen (mg/l)	0.3	.	0.2	.
Total phosphorus (mg/l)	less than 0.05	.	less than 0.05	.
Orthophosphate phosphorus (mg/l)	0.01	0.02	0.01	0.07
Alkalinity as $CaCO_3$ (mg/l)	177.0	219	171.5	194
Carbonate (meq/l)	0.00	.	0.00	.
Carbonate alkalinity (mg/l)	0.0	.	0.0	.
Bicarbonate (meq/l)	3.54	.	3.43	.
Bicarbonate alkalinity (mg/l)	216.0	.	209.3	.
Chloride by Autoanalyzer (mg/l)	9.20	.	6.37	.
Sulfate (mg/l)	68.8	67	64.1	65
pH	7.3	7.9	7.1	7.8
Total dissolved solids (mg/l)	296	230	244	208
Cadmium by ICP (mg/l)	less than 0.005	.	less than 0.005	.
Calcium by ICP (mg/l)	67.7	.	73.6	.
Chromium by ICP (mg/l)	less than 0.01	.	less than 0.01	.
Copper by ICP (mg/l)	0.040	.	.038	.
Lead by ICP (mg/l)	less than 0.05	.	less than 0.05	.
Magnesium by ICP (mg/l)	10.2	.	13.8	.
Mercury by ICP (mg/l)	less than 0.05	.	less than 0.05	.
Potassium by ICP (mg/l)	2.2	.	0.5	.
Selenium by ICP (mg/l)	less than 0.05	.	less than 0.05	.
Sodium by ICP (mg/l)	38.7	.	15.7	.
Electrical conductivity (uhos/cm)	483	420	431	355
Ammonium as nitrogen (mg/l)	0.08	.	0.06	.

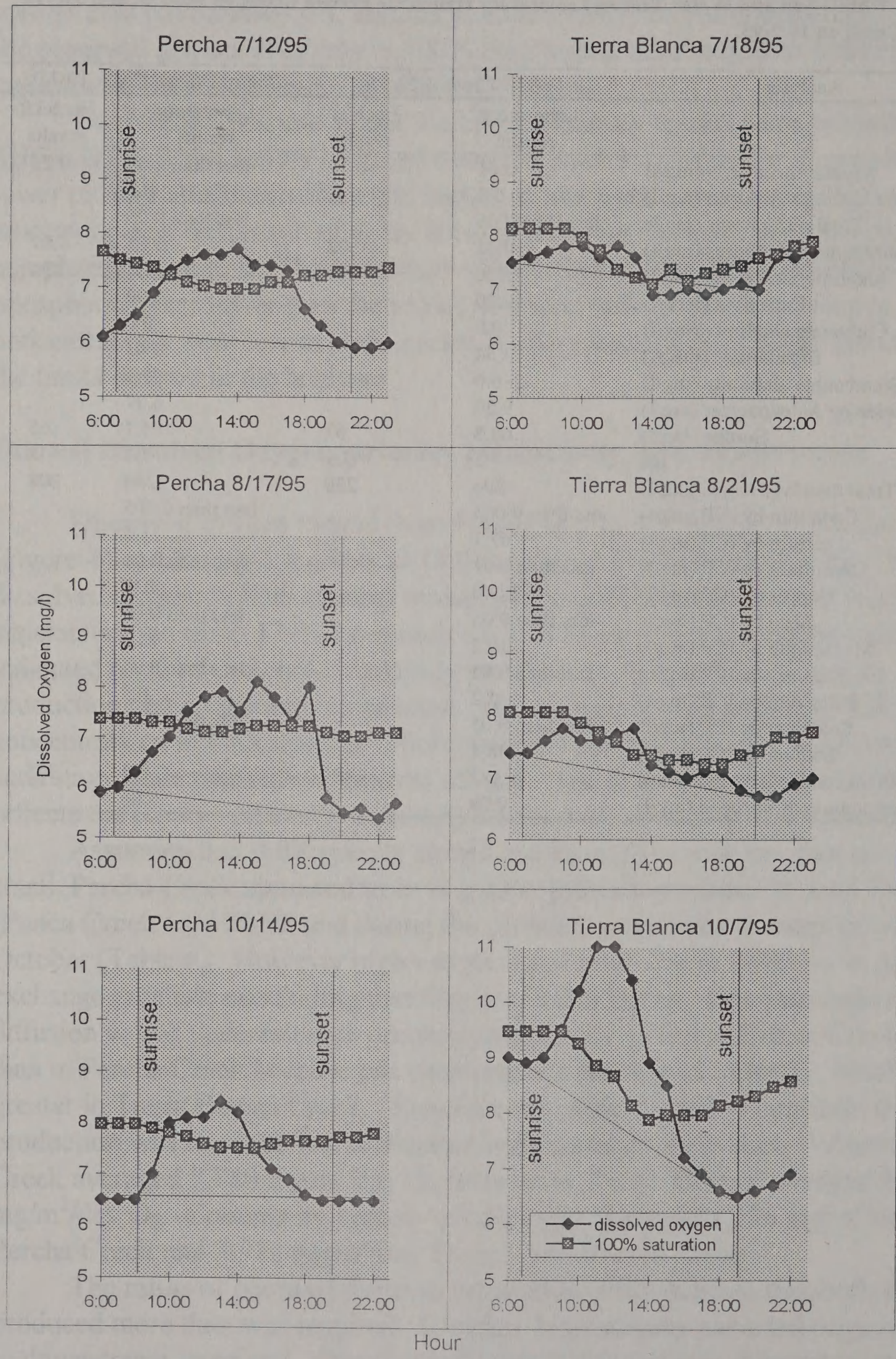


Figure 4. Diel dissolved oxygen profiles for Percha and Tierra Blanca Creeks.

Table 6. Estimated daily respiration and primary production based on diel dissolved oxygen curves from Percha and Tierra Blanca Creeks. Estimates were not corrected for diffusion and are therefore conservative.

Creek	Date	Respiration ($mg\ O_2/l/day$)	Respiration /area ($mgO_2/m^2/day$)	Primary Production ($mg\ O_2/l/day$)	Primary Production /area ($mg\ O_2/m^2/day$)	Primary Production/ Respiration	Cloud cover
Percha	7/12/95	16.8	3,024	23.6	4,248	1.4	clear
Percha	8/17/95	14.4	2,592	23.2	4,176	1.6	cloudy
Percha	10/14/95	16.8	3,024	20.8	3,744	1.2	clear
Percha mean		16.0 $\pm$0.8	2,880 $\pm$144	22.5 $\pm$0.9	4,056 $\pm$157	1.4 $\pm$0.12	
Tierra Blanca	7/18/95	16.8	1,848	19.6	2,156	1.2	cloudy
Tierra Blanca	8/21/95	14.4	1,584	18.0	1,980	1.3	cloudy
Tierra Blanca	10/7/95	31.2	3,432	43.9	4,829	1.4	clear
Tierra Blanca mean		20.8 $\pm$5.2	2,288 $\pm$588	27.2 $\pm$8.4	2,988 $\pm$922	1.3 $\pm$0.06	

sources. Most of the organic matter in the segments was produced *in situ*. Conversion of oxygen production to carbon production by a multiplier of 2.7 (based on atomic ratios of oxygen and carbon dioxide) and conversion to an areal basis (sum of the weight over a square meter), indicates mean productivities of 10.95 $\pm$ 0.43 g C/m^2/day at Percha Creek and 8.07 $\pm$ 2.5 g C/m^2/day at Tierra Blanca Creek.

Temperature fluctuated more in Tierra Blanca Creek than in Percha Creek (Figure 5), and highest temperatures were observed in Percha Creek. Night time cooling was greater in Tierra Blanca Creek than in Percha Creek. The difference in variation does not seem to be related to ground water influences. Ground temperature at stream segment elevation is about 17° C, significantly less than all temperatures observed in Percha Creek. Cloud cover may have been greater during evenings sampled at Percha Creek, although two out of three days were clear. Other micro-climate differences may result from topographic differences at the two sites. Greater canyon development in the Percha Creek segment may trap more heat during the day and maintain evening warmth longer than at Tierra Blanca Creek. Appendix B lists all dissolved oxygen and temperature readings taken.

Periphyton on Natural Substrates

Percha Creek accumulated significantly greater periphyton chlorophyll than Tierra Blanca Creek. Analysis of shaded substrates indicated that light probably limits growth in some parts of each stream. The shaded/unshaded ratio of chlorophyll a concentration on substrate was 0.39 at Percha Creek and 0.61 at Tierra Blanca Creek. The average of 0.05 indicates that productivity on illuminated substrates was twice that on shaded substrates. Tierra Blanca Creek was 1.6 times more shaded than Percha Creek. Therefore shade could be one explanation for what may be a lower primary production in Tierra Blanca Creek. Shaded substrates contained higher levels of chlorophyll b or c in two cases, perhaps due to experimental error.

There was no significant regression relationship between particle size and chlorophyll concentration under most of the conditions tested (Table 7). However, on 8/17/95, following a recent storm, substrates at Percha Creek revealed a significant relationship at $p=0.05$ (Chl a=19.844(particle diam.)-125.421, $R^2=0.739$, $p=0.039$). Under relatively stable hydraulic conditions at the relatively low mean velocities observed in the two streams, periphyton does not appear to be limited by shifting substrates. However, following elevated velocities, a relationship seemed to emerge in Percha Creek where substrates were less concreted and more likely to be moved by water flow than at Tierra Blanca Creek.

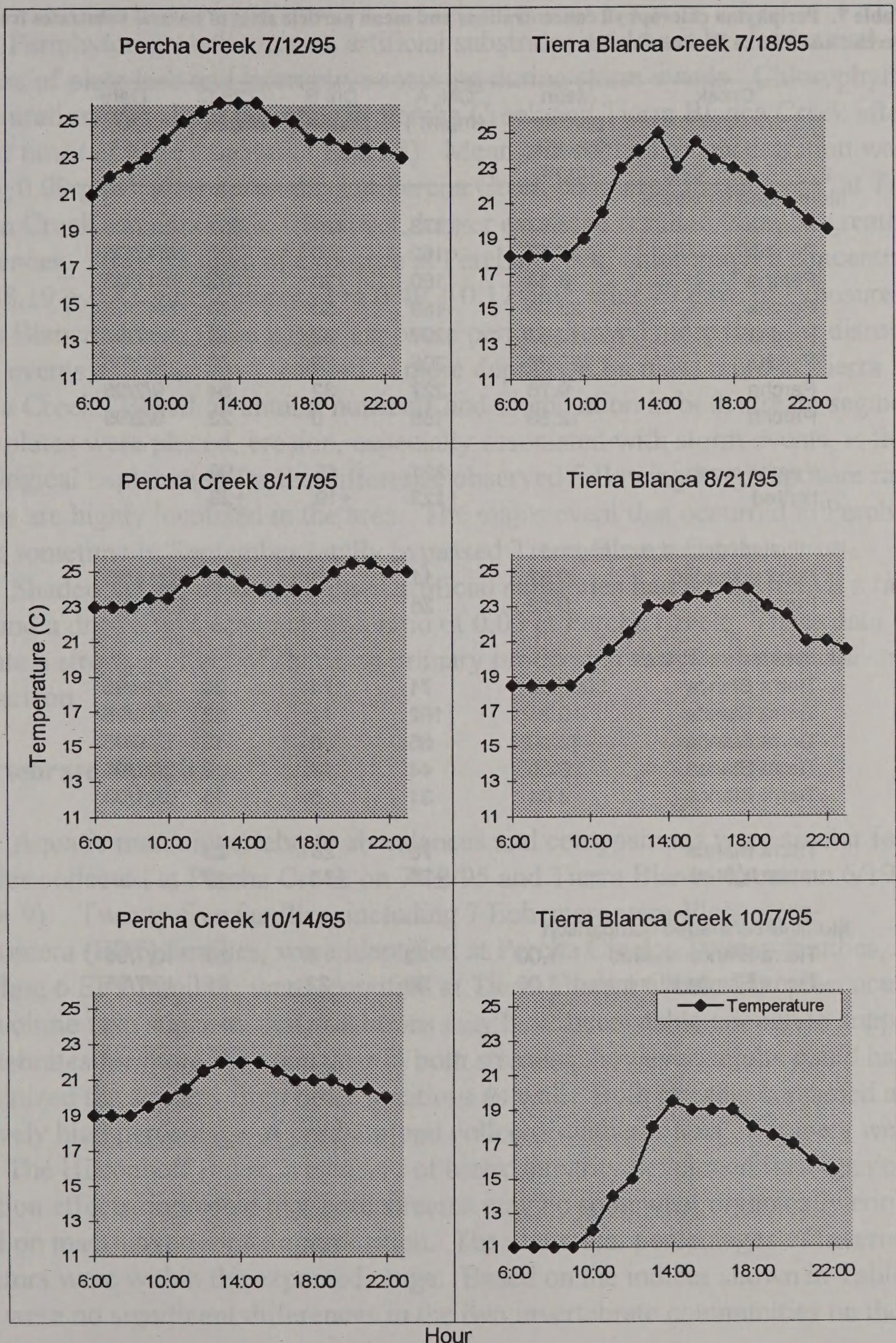


Figure 5. Temperature profiles for Percha and Tierra Blanca Creeks.

Table 7. Periphyton chlorophyll concentrations and mean particle sizes of natural substrates from Percha and Tierra Blanca Creeks.

Creek	Mean particle diameter (mm)	Chl. A (mg/m^2)	Chl B (mg/m^2)	Chl C (mg/m^2)	Date
Illuminated substrates					
Percha	58.84	1,173	171	232	8/17/95
Percha	25.55	192	0	132	8/17/95
Percha	8.38	160	30	82	8/17/95
Percha	25.99	159	50	80	8/17/95
Percha	12.67	297	47	133	8/17/95
Percha	129.68	205	29	52	9/2/95
Percha	9.76	227	32	54	9/2/95
Percha	12.36	155	0	23	9/2/95
Percha mean lighted		321 $\pm$123	45 $\pm$19	99 $\pm$23	
Illuminated/shaded comparison					
Percha shaded	0.52	11	16	0	10/14/95
Percha	0.52	28	1	8	10/14/95
Illuminated substrates					
Tierra Blanca	3000.00	71	75	30	7/19/95
Tierra Blanca	0.24	162	41	52	7/19/95
Tierra Blanca	12.00	65	6	10	7/19/95
Tierra Blanca	9.50	44	13	9	8/21/95
Tierra Blanca	3.04	31	5	15	8/21/95
Tierra Blanca mean lighted		75 $\pm$23	28 $\pm$13	23 $\pm$8	
illuminated/shaded comparison					
Tierra Blanca shaded	1.00	42	8	29	10/7/95
Tierra Blanca illuminated	1.00	69	22	21	10/7/95

Periphyton on Artificial Substrates

Periphyton growth rates on artificial substrates could not be determined because of plate loss and interuptive scouring during storm events. Chlorophyll concentration was about the same at Percha Creek and Tierra Blanca Creek after similar times of brief exposure (Table 8). Mean chlorophyll a concentration was 1.22 ± 0.00 g/m^2 after seven days at Percha Creek compared to 0.89 g/m^2 at Tierra Blanca Creek after six days. However, longer exposure resulted in much greater differences. After 23 days of exposure at Percha Creek, chlorophyll a concentration was 38.19 ± 0.81 g/m^2 compared to 0.49 ± 0.17 g/m^2 after 29 days of exposure at Tierra Blanca Creek. The longer exposure period allowed more time for disruptive storm events and may have resulted in more depressed biomass more at Tierra Blanca Creek. Based on similar nutrients and illumination in both stream segments when plates were placed, erosion, especially associated with storm events, is the most logical explanation for the difference observed following long exposure time. Storms are highly localized in the area. The major event that occurred in Percha Creek sometime in September totally bypassed Tierra Blanca Creek.

Shaded versus adjacent lighted artificial substrates had a chlorophyll a ratio of 0.15 and a dry-weight accumulation ratio of 0.05 at Percha Creek. These data indicate a stronger effect of shade on primary production than the natural substrate comparison.

Invertebrate Sampling

Aquatic macroinvertebrate abundances and compositions were similar for samples collected at Percha Creek on 7/12/95 and Tierra Blanca Creek on 6/19/95 (Table 9). Twenty-five families, including 7 Ephemeroptera-Plecoptera-Trichoptera (EPT) families, were identified at Percha Creek. Twenty families, including 6 EPT families, were identified at Tierra Blanca Creek. The presence of multivoltine taxa suggests that conditions may have been stable enough to support invertebrates for more than one year in both streams; however, adults could have recolonized the streams from other locations as well. Both streams contained a relatively high percentage of predator and collector-gatherer taxa. Scrapers were rare. The Hilsonhoff Index, a measure of biotic integrity developed for organic pollution effects, indicated that both streams may be somewhat organically enriched based on macroinvertebrate composition. The numerical percentages of invertebrate predators were within the expected range. Based on the indices shown in Table 9, there were no significant differences in the two invertebrate communities on these dates.

Table 8. Periphyton chlorophyll concentration and dry weight accumulation on artificial substrate in Percha and Tierra Blanca Creeks.

Creek	Date collected	Days in Creek	Dry weight accumulation ($g/m^2/day$)	Chl a (mg/m^2)	Chl b (mg/m^2)	Chl c (mg/m^2)
illuminated substrates						
Percha	6/15/95	7	0.66	1.22	0.81	1.41
Percha	6/15/95	7	0.06	1.22	1.27	1.92
Percha	6/19/95	11	8.46	24.92	25.51	28.97
Percha	6/19/95	11	0.31	3.02	1.36	1.98
Percha	6/19/95	11	1.50	13.46	7.65	11.92
Percha	10/14/95	23	3.18	39.54	37.58	45.98
Percha	10/14/95	23	4.01	38.31	35.26	43.41
Percha	10/14/95	23	4.61	36.73	32.56	39.34
Percha mean illuminated			2.85 $\pm$1.01	19.80 $\pm$6.06	17.75 $\pm$5.84	21.87 $\pm$6.96
illuminated/shaded comparison						
Percha shaded	10/14/95	23	0.09	10.19	1.43	3.26
Percha shaded	10/14/95	23	0.02	2.24	0.00	0.30
Percha shaded	10/14/95	23	0.52	4.83	0.00	0.82
Percha mean shaded	10/14/95	23	0.21 $\pm$0.16	5.75 $\pm$2.34	0.48 $\pm$0.48	1.46 $\pm$0.91
Percha illuminated	10/14/95	23	3.18	39.54	37.58	45.98
Percha illuminated	10/14/95	23	4.01	38.31	35.26	43.41
Percha illuminated	10/14/95	23	4.61	36.73	32.56	39.34
illuminated mean	10/14/95	23	3.93 $\pm$0.41	38.19 $\pm$0.81	35.13 $\pm$1.45	42.91 $\pm$1.93
illuminated substrates						
Tierra Blanca	6/15/95	6	0.01	0.89	0.24	1.18
Tierra Blanca	7/18/95	41	2.15	1.61	0.92	1.33
Tierra Blanca	7/18/95	41	1.21	0.94	0.48	0.77
Tierra Blanca	7/18/95	41	1.74	2.20	0.87	1.49
Tierra Blanca	7/18/95	29	0.18	1.19	0.79	1.07
Tierra Blanca	7/18/95	29	0.19	1.03	0.39	0.67
Tierra Blanca	7/18/95	29	0.84	0.99	0.61	0.87
Tierra Blanca	7/18/95	29	0.73	1.58	0.72	1.15
Tierra Blanca mean illuminated			0.88 $\pm$0.27	1.30 $\pm$0.17	.63 $\pm$0.09	1.07 $\pm$0.11

Table 9. Invertebrate sample results for Percha Creek on 7/12/95 and 9/22/95, and Tierra Blanca Creek on 6/19/95 and 10/7/95.

	Percha Creek		Tierra Blanca Creek	
	7/12/95	9/22/95	6/19/95	10/7/95
richness:	9.70 ± 2.70	2.50± 0.92	10.70 ± 2.10	11.67± 3.31
evenness:	0.77 ± 0.09	-	0.70 ± 0.06	0.58± 0.06
Shannon's H diversity index:	1.54 ± 0.26	0.13± 0.13	1.628 ± 0.29	1.39± 0.41
Modified Hilsenhoff biotic index:	4.55 ± 0.13	3.11± 1.04	4.65 ± 0.27	4.66± 0.12
Mean invertebrate abundance (number/m^2)	1,536± 1,373	16± 12	2,963± 1,901	1,620± 824
Mean predator abundance (number/m^2)	56± 32	2± 2	201± 104	124± 71
% mean predator abundance	3.6%	12.5%	6.8%	7.7%
Number of taxa caught by functional class:				
Shredders	3	0	3	4
Scrapers	1	0	1	2
Collector filterers	3	1	3	6
Collector gatherers	7	2	8	7
Predators	9	1	8	7
Unknown	1	1	1	2

Later sampling of Percha Creek on 9/22/95, following a storm event, and Tierra Blanca Creek on 10/7/95, revealed changes in macroinvertebrate abundances and compositions. Tierra Blanca had a higher proportion of collector-filterer taxa. Twenty-one families with 5 EPT families were identified. Percha Creek had only 3 families and 1 EPT family, indicating that storm events limit macroinvertebrate abundance and taxonomic richness at least periodically in these streams. The USDI BLM Aquatic Ecosystem Laboratory reports, which contain complete listings of macroinvertebrates sampled and additional indices, are attached as Appendix H.

Fish Sampling

Longfin dace, Agosia chrysogaster, and Rio Grande sucker, Catostomus plebeius, were the only fish species present in Percha Creek. Longfin dace redds and fry were observed throughout the study period, beginning on 4/30/95 and through 10/14/95.

Based on the length-weight relationship, individual mean weight for Longfin dace was 1.3 $\pm$ .004 g. There were 7.0 $\pm$ 0.5 dace/m^2, weighing 90.6 $\pm$ 90.8 kg/ha (Table 10). The mean weight for Rio Grande sucker was 5.2 $\pm$ .03 g. There were 1.1 $\pm$ 0.3 suckers/m^2, weighing 54.6 $\pm$ 68.7 kg/ha. Catch data are recorded in appendix C.

Length frequencies,estimated growth rates and productivity

Length frequency histograms (Figure 6.) had obvious peaks corresponding to year class averages at 25 mm and 65 mm length classes for Longfin dace, and at 45 mm and 95 mm length classes for Rio Grande sucker. Peaks for ages beyond the second year class could not be identified for either species.

Based on the length frequencies, growth rate for Longfin dace from age 1 to age 2 was about 40 mm or 2.5 g. A tentative productivity/biomass ratio based on one year of growth is 3.0. Growth for age one to age two Rio Grande suckers was about 50 mm or 6.4 g, with an estimated productivity/biomass ratio of 2.3. An approximate estimate of production for the fish populations is 270 kg/ha for dace, 124 Kg/ha for suckers, and 394 Kg/ha for both.

length weight relationship

Regression analysis of the natural log of weight as a function of the natural log of length revealed the following relationships:

Longfin dace $\ln W = -12.131 + (3.136)(\ln L)$ ($p<.00$, $R^2=.919$)

Rio Grande sucker $\ln W = -12.326 + (3.136)(\ln L)$ ($p<.00$, $R^2=.921$)

where ln W=natural log of weight and ln L=natural log of length (figure 7).

Table 10. Estimated abundance and biomass of Longfin dace and Rio Grande sucker in Percha Creek.

Spp	Reach	Estimated # fish in reach	Estimated # fish per m^2	Estimated # fish within BLM area	Estimated biomass (kg/ha)	Estimated biomass within BLM area (kg)
Longfin dace	1	689.2 ± 71.1	4.7 ± 0.5	17,865 ± 19,001	61.1 ± 61.4	23.2 ± 23.3
Longfin dace	2	773.6 ± 12.1	5.6 ± 0.1	3,801 ± 380	72.8 ± 72.8	27.7 ± 27.7
Longfin dace	3	1,163.6 ± 85.9	10.6 ± 0.8	40,291 ± 3,041	137.8 ± 138.2	52.4 ± 52.5
dace mean			7.0 ± 0.5	19,398 ± 7,474	90.6 ± 90.8	34.4 ± 34.5
Rio Grande sucker	1	failed	.	.	.	.
Rio Grande sucher	2	181.7 ± 40.6	1.3 ± 0.3	4,942 ± 1,140	67.6 ± 75.7	25.7 ± 28.8
Rio Grande sucker	3	88.5 ± 30.2	0.8 ± 0.3	3,041 ± 1,140	41.6 ± 61.7	15.8 ± 23.5
sucker mean			1.1 ± 0.3	3,992 ± 1,140	54.6 ± 68.7	27.3 ± 26.1

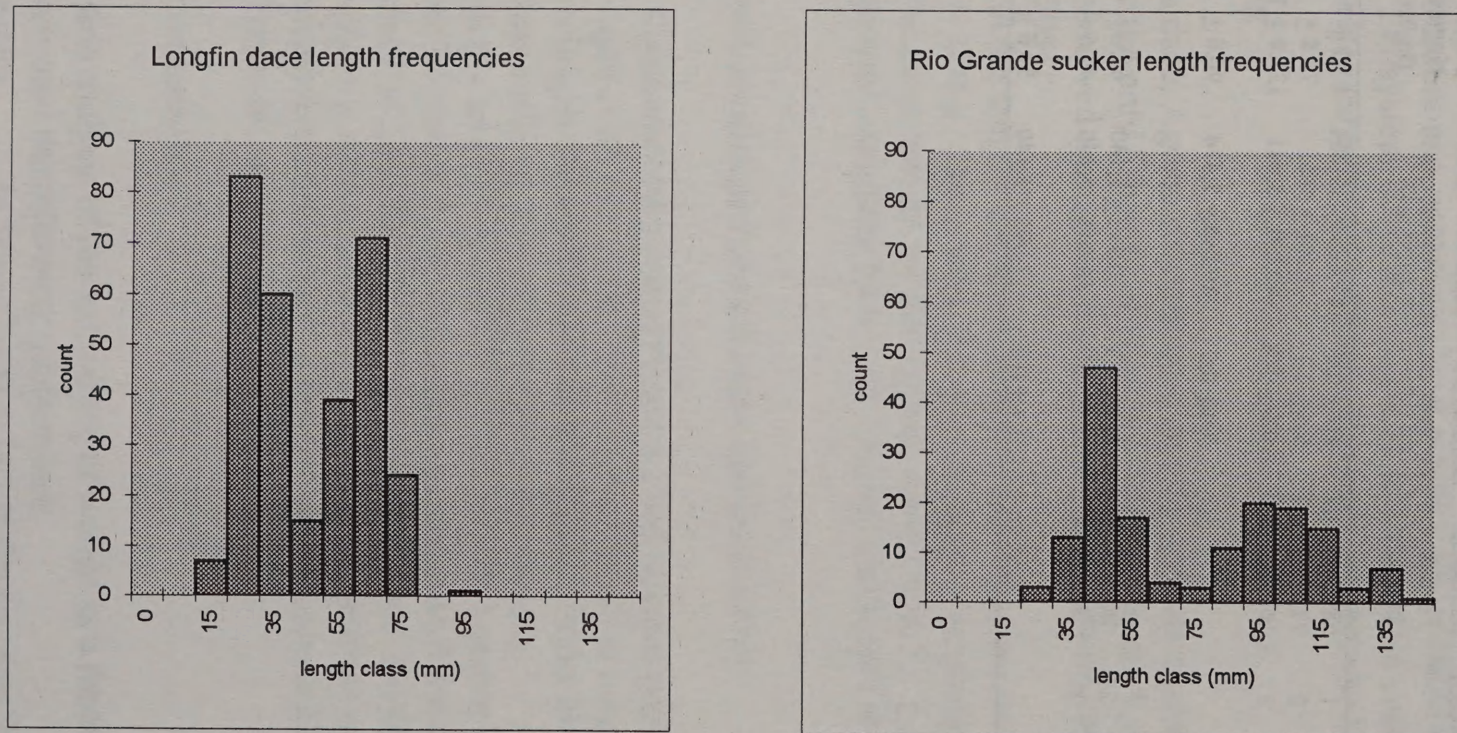


Figure 6. Length frequencies for Longfin dace and Rio Grande Suckers

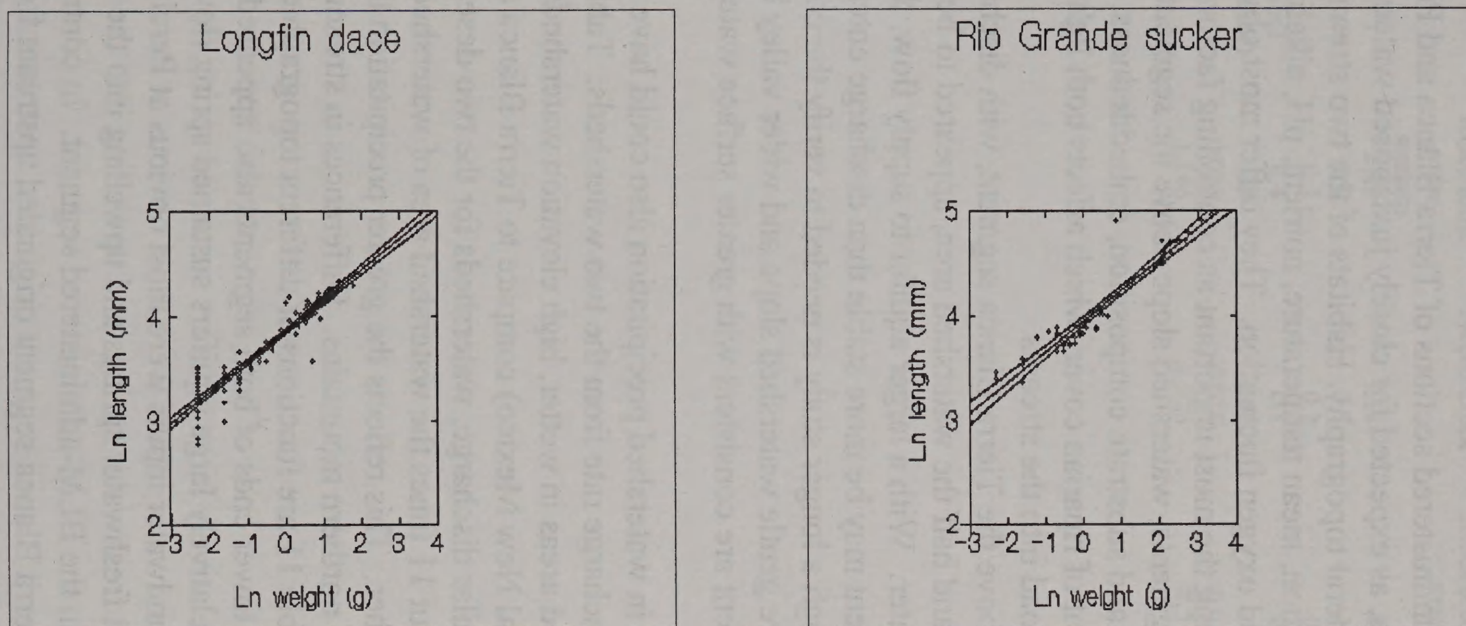


Figure 7. Regression relationship between natural log of length (mm) and natural log of weight (g) for Longfin dace and Rio Grande Suckers in Percha Creek.

DISCUSSION

Physical Habitat

The two BLM-administered sections of Tierra Blanca and Percha creeks are similar in many respects, as expected for closely juxtaposed watersheds with similar aspect, geology and general topography. Habitats of the two stream segments have similar discharge, elevation, mean temperature, nutrient, pH, alkalinity, ionic composition, salinity and oxygen fluctuation. They differ most obviously in certain physical attributes; among the most important as controlling factors are stream slope (gradient) within the segments, watershed slope above the segments, canyon width containing the streams, and substrate composition, embeddedness, and stability. They also differ in extent of riparian cover, which affects both light availability and allochthonous organic load into the streams.

The watershed above the Tierra Blanca segment, with discharge similar to the Percha Creek segment and half the watershed area, appeared to be more effective at accumulating groundwater. With a larger aquifer to supply flow, the discharge into the Tierra Blanca segment may be more stable than discharge entering the Percha Creek segment. Although a longer study is needed to verify the consistency of base flow discharge, the more gentle watershed slope and wider valley bottom serving the Tierra Blanca segment are consistent with greater surface water infiltration to subsurface aquifers.

Annual variation in watershed precipitation also could have contributed to the observed subsurface discharge rate from the two watersheds. Table 11 shows how discharge and watershed areas in wetter, high elevation watersheds of the Jemez Mountains (north central New Mexico) compare to Tierra Blanca and Percha Creeks. To sustain similar discharge, watersheds for the two desert stream segments averaged about 11 times the watershed area of watersheds at elevations about 1,000 meters higher. This reflects the greater precipitation that occurs at higher elevations in the northern mountains. Differences in stream slope, velocity and depth shown in Table 11 are functions of different topographies.

Base flow at the lower ends of both segments also appeared to be equally stable, indicating that relatively large aquifers sustained spring flows into both stream segments. Groundwater inputs were most obvious at Percha Creek, however, where several freshwater springs and upwelling into the channel more than doubled the discharge in the BLM-administered segment. In contrast, most of the water source for the Tierra Blanca segment originated upstream from the segment and surface flow diminished during passage through the segment as water sank below the surface. Evaporative loss was small, amounting to about 0.1 percent of discharge based on flow rate, surface area and high daily evaporation rates. The

Table 11. Stream morphology comparison between Jemez Mountain second and third order stream mean values (Soper 1983) and Percha and Tierra Blanca Creeks.

	Jemez third order streams	Percha Creek	Jemez second order streams	Tierra Blanca Creek
Watershed area (km^2)	27.7	218	6.8	95
Stream width (m)	2.9	3.0	1.0	2.1
Stream depth (m)	0.3	0.2	0.2	0.1
Water velocity (m/sec)	0.4	0.1	0.2	0.2
Stream discharge (l/sec)	33	49	30	40
Slope	0.033	0.018	0.030	0.025
Elevation	2,546	1,525	2,516	1,525

differences in water flux across the substrate surface at the two stream segments may have contributed to substrate differences that could explain, in part, why fish did not occur in the Tierra Blanca segment.

Upwelling is more likely to displace fine sediment downstream creating lower embeddedness, lower travertine formation, and more suitable substrate for fish spawning. Travertine, a precipitate mostly of calcium carbonate, appears to be more widespread in Tierra Blanca Creek than in Percha Creek. This precipitate occurs in limestone-rich spring-fed streams as groundwater with supersaturated concentrations of carbon dioxide comes to equilibrium with surface conditions. It causes concretion of sediments, increasing sediment stability while decreasing suitability as spawning substrate. Travertine may in part be more widespread in the Tierra Blanca segment because calcium carbonate precipitation usually occurs some distance downstream from springs and the spring sources were upstream from the segment, unlike Percha Creek, where springs emerged within the segment. The greater fluctuation of temperature observed in Tierra Blanca Creek also may be a consequence of spring sources being located some distance above the BLM-administered segment.

Hydrology and Riparian Vegetation

During the 1995 rainy season, flashy runoff had more obvious effect on the Percha segment than the Tierra Blanca segment. The difference was associated with one large event, which increased flow depth by at least 10 times base flow during September. Severe storm effects are often quite localized in southwestern watersheds, however, and one event during one summer does not substantiate less stable flows over the long run in Percha Creek. The September flash flood partially uprooted wetland plants and tree roots along the shore. Roots clearly resisted erosive forces, however, and maintained local substrate stability. The effects on the wetland plants bordering the stream were dramatic, revealing that discharge flashiness may partially explain why wetland plants are less common along Percha Creek than along Tierra Blanca Creek.

More important perhaps in controlling the extent of wetland plant growth were differences in depth of shore sediment above groundwater. Where fine sediments occurred, they tended to rise more steeply from the stream to greater depth above ground water in the Percha segment. The narrower valley width of the Percha Creek segment probably forces greater depth, velocity and erosive turbulence during flash flooding than occurs in the wider valley of the Tierra Blanca segment. Greater turbulence would raise stream capacity for transport of larger particles and result in more extended downstream transport. As the valley narrows and opens, it causes intermittent areas of erosion and deposition during flood events. Canyon widening in Percha Creek toward the lower end of the BLM-administered segment resulted in deep deposits of sandy sediment of a meter or more above

stream level and underlying groundwater. These sediments may be too deep for herbaceous wetland plant roots to reach groundwater and trees may develop long enough roots to reach permanent water only during the wettest growing seasons. The only area along Percha Creek supporting significant growth of wetland plants occurred in a wider than average location in the valley upstream from a debris dam created from landslides off the steep valley walls and downstream from a narrow box canyon. Alluvium from the box accumulated behind the debris dam, which also raised groundwater level high enough to support significant wetland plant growth.

The steeper watershed above and narrower canyon topography around the Percha Creek segment create conditions that probably supply greater amounts of large rocks to the stream channel than at Tierra Blanca Creek. Soper (1983) also found that substrate size increased as stream order and valley depth increased on the slopes of the Jemez mountains in northcentral New Mexico. The larger rock debris in Percha Creek creates a series of debris dams throughout the segment, behind which large pools form. In contrast, pools were smaller and had higher velocity in Tierra Blanca Creek because channel slope was greater and there were fewer boulder dams formed by landslides in the wider valley. This resulted in more continuous accumulations of alluvium behind geological control points and more extensive accumulation of shallow sediment just above groundwater level, where wetland plants could flourish. Such areas also were more conducive to establishment of riparian trees because tap roots could reach groundwater with less summer precipitation than at Percha Creek. Greater riparian growth resulted in more summer shade directly over the stream and more organic loading from riparian tree leaves.

Stream Organic Loading Impacts

The streams had high enough concentrations of dissolved phosphorus and nitrogen to sustain high primary production. Phosphorus concentrations were about five times higher than concentrations often considered sufficient for eutrophication (Wetzel 1983) . Nitrogen appeared to be the limiting nutrient, but light and erosive scouring probably contributed to limiting primary production. Because of the eastern aspect and steep canyon topography, both stream bottoms are illuminated most intensely in early morning and become shaded in afternoon. Probably because of this shade effect, photosynthesis-generated oxygen decreased earlier in the day than it would in streams surrounded by flatter topography. Although the shade generated by overhead riparian cover at Tierra Blanca Creek may limit production more so than at Percha Creek, topographic shade may be the more important factor. A more complete analysis would more completely quantify changes in light over a diurnal cycle.

High nutrient concentrations appeared to originate naturally from soluble volcanic and limestone rock formations in both watersheds (Jicha 1954, Kuellmer

1954), rather than from obvious anthropogenic sources. Old mines may contribute, but there was little indication from metal concentrations (low copper concentration) that such sources might be important. Both watersheds have very low human population densities. Livestock may contribute to nutrient loading in the upper watersheds, but spring water concentrations of phosphorus and nitrogen indicate that livestock were not an important local source of nutrient during this study.

Nutrient concentrations in other locations in New Mexico, shown in Table 12, indicate that concentrations are not inordinately high for streams with no impoundments upstream. Concentrations in the Rio Grande below dams are among the lowest in part because nutrients are trapped in large reservoirs (Cole et al. 1985). Percha and Tierra Blanca creeks are similarly or less enriched than other monitored undammed streams in New Mexico. They are much less enriched in nitrogen than desert spring-flows at Owl and Chosa Draws in southeastern New Mexico (Keeler-Foster 1995). Those springs occur in gypsum-rich watersheds with high sulfate concentration and high watershed solubility.

Although estimated gross primary production was high in the two stream segments compared to other stream sites, they were not extraordinary (Minshall 1978) . Conversions to Kilocalories of energy (based on carbon being 40% of organic matter dry weight and 4,000 calories/gram of organic matter) allowed comparison to data summarized by Minshall 1978) and indicate that primary production averaged about 30 kcal/m^2/day at Tierra Blanca Creek and 40 kcal/m^2/day at Percha Creek. These productivities were similar to daily primary production estimated for Owl and Chosa springs in southeastern New Mexico (Keeler-Foster 1995). Minshall (1978) summarized primary productivities for 14 stream sites, which ranged from 0.03 to 60.6 kcal/m^2/day with four streams having higher productivity than Percha and Tierra Blanca creeks. Minshall (1978) also showed that primary production was consistently much lower in streams with dense riparian canopies, but allochthonous organic load from leaf fall to some extent compensated as an energy source where primary production was reduced by shade. Desert streams are typically among the most productive and tend towards natural eutrophy.

Donaldson (1987) showed a relationship between canopy cover and allochthonous organic load to the Rio Grande near the mouth of Percha Creek. At 100% cover she estimated a riparian input of about 400 gC/m^2/yr based on deciduous input during October and November. Assuming a similar relation between cover and leaf input, allochthonous organic load from the riparian zone was about 100 gC/m^2/yr in Percha Creek and 160 gC/m^2/yr in Tierra Blanca Creek. If the average daily gross primary production at the two stream segments is assumed to equal an annual mean, annual organic load would sum to 1,480 gC/m^2/yr at

Table 12. Comparison of Percha and Tierra Blanca mean water chemistry values (ranges) with other New Mexico sites.

Analysis	Caballo[a]	Gila[b]	Leasburg[c]	Mogollon[d]	Below Caballo[e]	Jemez second order[f]	Jemez third order[g]	Chosa[h]	Owl[i]	Percha Creek	Tierra Blanca Creek
Conductivity (uhos)	1322 (950-2010)	292 (107-392)	1240 (672-1515)	89 (50-135)	474 (468-480)	270 .	120 .	3,300 .	5,000 .	429 (370-480)	399 (355-430)
pH	8.5 (8.2-8.8)	8.2 (7.3-9.0)	8.3 (7.7-9.3)	7.8 (7.0-8.5)	. .	7.6 .	7.5 .	7.9 .	8.5 .	7.6 (7.0-7.9)	7.6 (7.0-8.2)
Alkalinity (mg/l $CaCO_3$)	208 (173-274)	115 (51-249)	213 (118-225)	44 (9-590)	.	130 .	42 .	135 (82-191)	118 (106-125)	169 (139-219)	143 (92-194)
Sulfate (mg/l)	281 (190-470)	28 (9-47)	295 (120-380)	10 (6-18)	. .	10 .	6 .	1750 (1600-2000)	1950 (1700-2400)	65 (49-80)	55 (43-70)
Nitrate-nitrogen (mg/l)	0.46 (<0.05-1.00)	0.30 (<0.05-.50)	0.22 (<0.05-0.50)	0.05 (<0.05-0.17)	0.02 (0.01-0.03)	0.10 .	0.18 .	3.20 (0.20-8.00)	2.90 (0.40-4.13)	0.52 (0.00-1.50)	0.45 (0.00-1.50)
Orthophosphate phosphorus (mg/l)	0.13 (0.04-0.42)	0.05 (<0.01-0.19)	0.01 (<0.01-0.05)	0.02 (0.01-0.14)	0.01 (0.01-0.04)	0.10 (total P)	0.10 (total P)	0.05 (0.04-0.06)	0.04 (0.02-0.06)	0.06 (0.01-0.13)	0.07 (0.03-0.14)

[a] Rio Grande at Caballo Dam, 1991-1992 (USGS Water Resources Data)
[b] Gila River near Redrock, 1985-1994 (USGS Water Resources Data)
[c] Rio Grande at Leasburg, 1988-1994 (USGS Water Resources Data)
[d] Mogollon Creek near Cliff, 1985-1994 (USGS Water Resources Data)
[e] Rio Grande below Caballo Dam during summer of 1986 and 1987 (Donaldson, 1987)
[f] Jemez mountain second order streams (Soper, 1983)
[g] Jemez mountain third order streams (Soper, 1983)
[h] Chosa Spring near Carlsbad 1993-1994 (Keeler-Foster, 1995)
[i] Owl Spring near Carlsbad 1993-1994 (Keeler-Foster, 1995)

Percha Creek and 1,050 $gC/m^2/yr$ at Tierra Blanca Creek. Thus the contribution by riparian communities of organic matter to stream energetics is relatively low in the two creek sections, probably less than 20% of the total organic load at both locations. Minshall (1978) shows that the riparian contribution is commonly low for those desert streams and large rivers that had been measured up to the time of this study.

The mean periphyton growth on natural substrates of Tierra Blanca Creek compared quite closely to what Donaldson (1987) found in the Rio Grande below Caballo Reservoir. Percha periphyton on natural substrates was about 16 times as dense. On artificial substrates, comparisons with USGS monitored sites (USGS 1979-1980) revealed high variation among sites and a large difference between Tierra Blanca and Percha creeks, probably because of the variable effects of runoff events on periphyton erosion (Table 13). The scouring effect was most noticed in Percha Creek, which had very high accumulations of periphyton, especially in pools, before summer storm events began to occur regularly. Periphyton biomass was greatly depressed following the large event in September. The consistently lower periphyton biomass in Tierra Blanca Creek may have been sustained by greater erosion caused by greater mean velocity in Tierra Blanca Creek.

Aquatic Invertebrates

Aquatic macroinvertebrate diversity (Shannon-Weiner Diversity) was relatively low and similar for both BLM-administered stream segments during the summer. The low diversity might be associated with increased organic loading from eutrophication. Cole (1973) found macroinvertebrate diversity was halved by cultural eutrophication that created mean diversities (1.78) similar to those in Percha and Tierra Blanca creeks. The agent most often connected to decreased diversity from high organic loading is oxygen depletion, which was sustained at relatively high concentrations in the two stream segments during the three times studied. If oxygen never fell below concentrations observed during the study, we doubt that it was entirely responsible for the observed low diversity.

An index of biotic integrity (Hilsonhoff 1987, 1988) for the two stream segments suggested that they suffered from moderate effects of elevated organic loading. The index was developed for cool streams in the northern U.S. (Hilsonhoff 1987), however, where stream density is high. Uncritical application to more isolated warm desert streams may risk confusion with zoogeographical effects associated with small habitat size and low perennial stream density. The presence of at least some taxa intolerant of organic loading suggested that conditions associated with elevated organic loading from high primary production were not as important as other limiting factors. Also, low abundance of certain tolerant groups, such as pulmonate snails, indicates that other factors are operating.

Table 13. Comparison of periphyton growth between Percha and Tierra Blanca Creeks and USGS sites in New Mexico.

Site	Chlorophyll a (mg/m^2)	days of exposure
Percha Creek mean	19.8	15
Tierra Blanca Creek mean	0.9	27
Gila River 1979	1.0	25
Gila River 1980	5.3	29
Mimbres River 1980	23.5	30
Mimbres River 1980	28.2	42
Elephant Butte Reservoir 1979	1.8	22
Elephant Butte Reservoir 1979	18.5	26
Elephant Butte Reservoir 1980	23.3	25
Elephant Butte Reservoir 1980	29.4	28
Elephant Butte Reservoir 1980	10.6	38

Theory of island biogeography (MacArthur and Wilson 1967) suggests that more broadly adapted species are often among the most fecund and vagile, and among the first to colonize a new or disturbed habitat. We would expect that a relatively large fraction of taxa present in frequently disturbed (by flash flooding) remote and small habitats, like the two stream segments, would be inhabited by a disproportionately large fraction of broadly tolerant species. We suspect that discharge flashiness, extreme desert temperature, small habitat size, and habitat isolation within the watershed ecosystem naturally result in relatively low biodiversity, fluctuating biomass, and fluctuating production compared to larger, less isolated and more physically stable aquatic ecosystems. Stream-flow flashiness is a natural consequence of arid watershed condition, steep slopes and intense summer storms. It may be aggravated by land management practices that diminish rainfall infiltration, but flash flooding quite probably denuded desert streams with steep watersheds in the pristine state. Flying invertebrates are among the most vagile, thus low abundances of non-flying taxa, such as snails, are to be expected where flashy runoff has been recent or is frequent.

The number of invertebrate families found in the two streams was higher (Table 14) than in other relatively isolated desert streams in New Mexico and Arizona (Chosa Spring, Owl Spring, and Aravaipa Creek). The highest number of families was for a region in the Jemez Mountains with numerous perennial streams. Fish were present in all of the sites shown in Table 14 except Tierra Blanca Creek. There is little indication that fish depressed the number of invertebrate families in Percha Creek or caused other differences observed between Tierra Blanca and Percha Creeks.

The best tentative explanation for numbers of taxa present is the periodic effect of scouring flood and the isolation of the communities from communities at similar elevations. Fisher et al. (1982) found that flash flooding nearly eliminated macroinvertebrates, as we observed in Percha Creek on 9/22/95, but that recovery was rapid as flying aquatic insects recolonized from undisturbed sites. Based on Island biogeography theory (MacArthur and Wilson 1967), small and isolated streams would have a lower mean taxon number than larger and closely situated streams. Simberloff (1976) verified important elements of MacArthur's and Wilson's (1967) theory with experiments.

The fraction of families in the Ephemeroptera, Plecoptera and Trichoptera is relatively low in all of the lower elevation desert streams (Table 14). Although not identified to family by Keeler-Foster (1995), only 1 Ephemeropteran species and no Trichoptera or Plecoptera were found in Owl and Chosa springs. These insect orders typically are most diverse in colder streams at higher elevations, such as streams in the Jemez Mountains. Not much is known about upper thermal tolerances of many insect families. Jacobi et al. (1995) showed that elevation is inversely related to the number of invertebrate taxa in northern New Mexico, which

Table 14. Comparison of aquatic invertebrate families and functional groups in various New Mexico sites.

	Number of families	Number of EPT families	% Scrapers	% Predators	% Collector-filterers and gatherers	% Shredders
Jemez second order streams[a]	44	22	20	19	58	3
Jemez third order streams[a]	48	24	11	7	48	34
Chosa Spring[b]	8	.	.	.	.	.
Owl Spring[b]	13	.	.	.	.	.
Rio Grande[c]	13	7	.	.	.	.
Aravaipa Creek, AZ[d]	12	6	1	13	87	1
Percha Creek	25	7	1	10	77	12
Tierra Blanca Creek[e]	20	6	0	18	73	2

[a] Soper 1983
[b] Keeler-Foster 1995
[c] Desmare 1978
[d] Fisher et al. 1982
[e] 7% unknown

in part could be associated with higher temperature at lower elevations. An extension of a regression developed by Jacobi et al. (1995) predicts that 15 to 16 taxa would be expected at the elevation of the Percha and Tierra Blanca segments, a number less than the number of families observed at the two study sites.

The fractional composition of functional groups (Merritt and Cummins 1984) revealed one inconsistency with the high periphyton abundance at the two study streams. Invertebrates that scrape periphyton from substrates were relatively scarce at Percha and Tierra Blanca Creeks as they were at Aravaipa Creek in Arizona, another isolated desert stream. Relatively few insect families are scrapers and they may be less vagile than other functional groups. Snails are the major non-insect group of scrapers and are less vagile than flying taxa.

In contrast, the fraction of invertebrates that collect food particles from bottom or from the current was quite high in the desert streams and much higher than the fraction of taxa that shred coarse organic matter. Shredders are relatively common where riparian leaf input or aquatic macrophyte production is a high fraction of the total organic load, which was not the case in the two stream segments or in other desert streams. The high fraction of collectors indicated that most invertebrates fed on periphyton once it was dislodged by erosion, or on the feces of periphyton-feeding invertebrates. A filter-feeding dipteran, in the Simulidae (blackflies), was the most common collector present. They are vagile and have numerous generations annually, thus they are often among the first families to recolonize a stream once it has been denuded by flooding.

Predators made up similar percentages across all stream elevations. The consistency of an average percentage near 10% indicates that food chains are of similar length in all the streams including Tierra Blanca and Percha Creek and the percentage is consistent with trophic theory, which predicts a mean trophic level net production efficiency of 5 to 15% (Koslovsky 1968) in generally undisturbed environments.

Fish

One of the most obvious differences between the two study segments was the presence of fish in the Percha Creek segment and their absence in the Tierra Blanca segment. Mark Hakkila (BLM, personal communication) indicated he recently observed sucker-like fish in the headwaters of Tierra Blanca Creek. We have not confirmed that the fish were Rio Grande suckers, but suspect they are because of their locally widespread distribution. Dr. Paul Turner (NMSU, personal communication) confirmed that both Rio Grande suckers and longfin dace are present in Animas Creek, one major drainage north of Percha Creek. We confirmed that Rio Grande suckers are present in Berrenda Creek, one major drainage south of Tierra Blanca Creek. According to Sublette et al. (1990), Rio Grande suckers also occur somewhat farther north along the Black Range in Alamosa Creek. Thus Rio

Grande suckers are widely dispersed among those streams draining eastward from the Black Range to the Rio Grande as well as other streams scattered throughout the upper Rio Grande watershed. Presumably, they colonized the streams during wetter periods in the distant past, when the streams were perennial throughout their entire length. They are now disconnected from the Rio Grande under all but the most extreme runoff conditions. No one knows if they are genetically distinct from populations elsewhere in their range.

Both fish species in Percha Creek are being considered for endangered species listing. Of the two species, Rio Grande suckers are more widely distributed, but may be declining at a faster rate, because of competition and integradation with the closely related white sucker, *Catostomus commersoni* (Michael Hatch, NMGF; Robert Calamusso 1992--personal communications), which colonized the Rio Grande relatively recently and appear to be expanding their distribution. Because the streams draining the Black Range are isolated from ingress by white suckers, they may become significant refuges for protecting Rio Grande suckers in the future.

Longfin dace are not believed to be native to the Rio Grande watershed (Michael Hatch, NMGF; personal communication) and their few locations in the Rio Grande watershed are easiest to explain as human-caused introductions from the Gila River watershed. If they have been introduced to Percha Creek as believed, they form part of a culturally modified community, which may have had some impact on community structure. However, they too may prove to be a sensitive species within their native range. Their location by introduction outside their native range may increase their genetic viability and raise the total value of the Percha Creek segment as a refugium for sensitive fish species. What benefits are foregone as a consequence of management designed to sustain longfin dace there? We do not know. However, the ecosystem properties of the two segments, with and without fish, are quite similar, indicating that the fish probably played a relatively small role in determining ecological functions at the fairly broad level of community integrity measured by our indices.

How do fish measures of stream community integrity in the Percha Creek segment compare to other stream locations? The low number of fish species in small streams discharging to lower elevations in the Black Range is predicted by a regression relating fish species number to elevation defined by Cowley and Sublette (1987). Keeler-Foster (1995) found 2 to 3 fish species (one probably introduced) in isolated springs near the Black River, a number smaller than expected based on elevation as a predictor. A similar extrapolation from a relationship between elevation and fish species developed in northern New Mexico (Jacobi et al. 1995) predicts far too high a species number at the two sites. We agree with Jacobi et al. (1995) who concluded that such biotic indices for fishes need to be geographically more specific than the large area represented by New Mexico. We suspect, however, that an index based on stream size (e.g., width, depth, discharge or channel order) and isolation from other streams (e.g., stream density, extent of

subterranean flow, channel gradient) would be a much better predictor of fish species number over a larger geographical area.

Why are Rio Grande suckers not present in the Tierra Blanca segment administered by BLM if they are present upstream? More than likely the species was present in the segment at some time in the past, and could become established again when young fish are carried by storm flow the 10-kilometer distance down the channel. We suspect that such colonization may occur, but conditions in the Tierra Blanca segment cannot sustain the suckers. We suspect that small pools, relatively high slope and velocities, and concreted sediments combine to create marginal habitat. Even if adult fish were to become established by recolonization or introduction, concreted and embedded sediments and unsuitable stream hydraulics may preclude their reproduction. Confirmation of sucker presence upstream and the conditions they inhabit is preliminary to any further consideration of the role suckers once may have played or might play in future re-establishment at the Tierra Blanca segment.

Should suckers be introduced into the Tierra Blanca segment if they are in the upper watershed already? We do not know what ecological services now provided by the Tierra Blanca segment might be lost as a consequence, especially related to support of possibly unique invertebrate species. A worse case scenario would include just enough success with fish introduction to cause decreased genetic diversity of other taxa followed by the loss of the introduced fish population during extreme conditions.

The data presented here for fish populations indicate that a significant biomass and production of fish existed, well within the amounts measured in other stream sites (Chapman 1978) and similar to unfished trout populations at higher altitude in northern New Mexico (Cole et al. 1993). Based on length-frequency data both populations are reproducing. Longfin dace spawning was observed throughout the study period following onset of the rainy season. Exactly how the fish fit into the food web is not well understood. Both species consume algae and invertebrates (Sublette et al. 1990), but the extent of algal assimilation is unknown. Based on our estimated net productions of periphyton (assuming half the gross production supports periphyton respiration) and fish, the trophic conversion from periphyton to fish is close to the average of 1% expected for carnivores (0.45%). If they are primarily herbivores (which is less likely), the trophic conversion is much lower than expected. A low trophic conversion would signal an especially harsh or unstable environment for the two fish species.

Study Limitations

Results of this study are limited by natural variation in sampled parameters and the extent to which larger ecosystem process is considered. This becomes especially evident in any attempt to link differences in riparian condition at the two

study sites to differences in topography and range management. In assessing whether indices of aquatic community integrity deviate from some expectation of a "proper" ecosystem integrity, the reliability of that parameter as a measure and the statistical confidence in its measure both are critical.

The status of fish populations is a relevant example. The two species in Percha Creek cannot be judged to be of special concern in terms of maintaining genetic integrity until all of the Rio Grande watershed and upper Gila watershed ecosystems are examined for the status of those species. How important are the few fish that may be sustained in Percha Creek? What fraction of the entire populations existing throughout the watershed do they compose? Are they genetically distinct? Do the populations "come and go" over time through natural process? Would recovery by reintroduction be justified if they do prove to have highly variable abundances prone to local extinction? How does their status compare to other needs in the Rio Grande and Gila watersheds? We do not know because both biological and social data are lacking throughout the ecosystems that make up their range and studies tend to be local, parochial, politically fragmented (various agencies doing their own thing), and insufficiently integrated over the full range of biological and social concerns.

BLM is responsible for management of most of the public lands bordering desert streams in the U. S., and especially stream systems with scattered and isolated perennial flows. Habitat isolation is an engine for genetic diversification, which is evident in unique fish and invertebrate populations associated with isolated waters. Habitat isolation also should be considered in making inferences from more general measures of community integrity developed for areas with greater natural habitat density and stability, such as biodiversity and indices of biotic integrity. Detailed study of ecosystem dynamics for desert streams is sparse. Only rudimentary understanding exists about how desert stream integrity is maintained by natural ecosystem instability, isolation mechanisms, and recolonization process. Although rangeland management impacts on cold trout streams in mesic watersheds have been studied in some detail (Meehan 1991), the findings may not apply to lower-elevation desert streams.

Considerations

For future consideration in monitoring, management and original study of desert-stream ecosystem integrity, BLM should consider the following:

1. Biotic indices and other indices of community integrity developed for streams in wetter and colder climates on gentle slopes should not be assumed to have the same implications in steep, hot, and dry watersheds.

2. Expectations for desert-stream community integrity need to consider the natural constraints associated with flashy discharge and spatially and temporally intermittent flows.

3. Those who measure desert-stream community integrity need to consider ecosystem processes that result in periodic local extinction and recolonization from a network of similar habitats in the ecosystem.

4. Understanding of rangeland management impacts on cold water streams and salmonids should not be assumed to apply to warm-water streams and non-salmonid fish populations without adequate testing.

5. Cultural modifications of arid-land landscapes by livestock grazing have been so geographically widespread that development of ecosystem indices based on recent and future floral and faunal distribution surveys are likely to incorporate grazing impacts, perhaps establishing an unwarranted legitimacy for past management practices.

6. Desert streams are rare enough, unique enough, and important enough as reservoirs of genetic information to invest more research into more suitable measures of ecosystem integrity than have so far been conducted.

7. Although local monitoring following changes in management policies is good practice, until clearer standards for appropriate measures of and desirable levels of ecosystem integrity are developed, monitoring results are likely to be of limited value.

8. Desert stream systems are highly variable and will require greater sampling intensity to identify significant management impacts on ecosystem integrity than more stable ecosystems elsewhere.

LITERATURE CITED

Calumusso, B. 1992. Current distribution of *Catostomus plebeius* and *Gila pandora* on the Carson National Forest, New Mexico with preliminary comments on habitat preferences. Proceedings of the Desert Fishes Council. 24:63-64.

Chapman, D. W. 1978. Production in fish populations. Pages 5-25 *In* S. D. Gerking, ed. Ecology of freshwater fish production. Blackwell Scientific Publications. London, England

Cole, G. A. 1983. Textbook of limnology. Third edition. C.V. Mosby Company. Saint Louis.

Cole, R. A. 1973. Stream community response to nutrient enrichment. Journal Water Pollution Control Federation. 45:1874-1888.

Cole, R, R. Deitner, G. Marracchini, R. Akroyd, and M. Hatch. 1993. Quality trout water evaluation. Final Report, Study No. 104, Federal Aid Project F-22-R-33, New Mexico Department of Game and Fish. Santa Fe, NM

Cole, R., R. Deitner, R. Tafanelli, G. Desmare, and P. Turner. 1985. Trophic model development for reservoirs in New Mexico. Final Report, Federal Aid Project F-53, New Mexico Department of Game and Fish.Santa Fe.

Cowley, D. E. and J. E. Sublette. 1987. Distribution of fishes in the Black River drainages, Eddy County, New Mexico. Southwestern Naturalist. 32:213-221.

Desmare, A. G. 1978. Changes in water quality and fish fauna in the Rio Grande between Elephant Butte Dam and Caballo Lake. M.S. Thesis, New Mexico State University, Las Cruces.

Donaldson, M. C. 1987. Primary production and organic loading in the Rio Grande tailwater of Caballo Reservoir. M.S. Thesis, New Mexico State University, Las Cruces.

Fisher, S.G., J.G. Lawrence, N.B. Grimm, D.E. Busch. 1982. Temporal succession in a desert stream ecosystem following flash flooding. Ecological Monographs. 52 (1):91-110.

Franson, A.H., A.E. Greensberg, R.R. Trussell, L.S. Clesceri, eds. 1985. Standard methods for the examination of water and wastewater. Sixteenth edition. American Public Health Association, American Water Works Association, Water Pollution Control Federation. Washington D.C.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist. 20:31-39.

Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family level biotic index. Journal of the North American Benthological Society. 7:65-68.

Jacobi, G. Z., J. E. Sublette, S. Heirman, M. D. Hatch, and D. E. Cowley. 1995. Development of an index of biotic integrity utilizing aquatic

macroinvertebrates for use in water resources and fishery management. Performance Report, Project No. 01, Federal Aid Grant F-59-R-4, New Mexico Department of Game and Fish. Santa Fe, NM

Jicha, H.L. 1954. Geology and mineral deposits of Lake Valley quadrangle, Grant, Luna, and Sierra Counties, New Mexico. Bulletin #37. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology. Soccorro, NM.

Keeler-Foster, C. 1995. An ecological pilot study of two rheocrene springs in Eddy County, New Mexico. M.S. Thesis, New Mexico State University, Las Cruces.

Koslovsky, D. G. 1968. A critical evaluation of the trophic level concept. I. Ecological efficiencies. Ecology. 49:48-60.

Kuellmer, F.J. 1954. Geologic section of the Black Range at Kingston, New Mexico. Bulletin #33. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology. Soccoro, NM.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial Processes in Geomorphology. W.H. Freeman and Company. San Francisco, CA.

MacArthur, R. H and E. O. Wilson 1967. The theory of island biogeography. Princeton University Press. Princeton, NJ.

Meehan, W. R., ed. 1995. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19, American Fisheries Society. Bethesda, MD

Meffe, G.K. and W.L. Minckley. 1987. Persistence and stability of fish and invertebrate assemblages in a repeatedly disturbed Sonoran Desert stream. American Midland Naturalist. 117:177-191.

Merritt, R.W. and K.W. Cummins, eds. 1984. An introduction to aquatic insects. Second edition. Kendall/Hunt. Dubuque, IA.

Minshall, G. W. 1978. Autotrophy in stream ecosystems. Bioscience. 28:767-771.

Odum, H.T. 1956. Primary production in flowing waters. Limnology and Oceanography. 1:102-117.

Orth, D.J. 1983. Aquatic Habitat Measurements. Pages 61-84 *in* L.A. Nielsen and D.J. Johnson eds. Fisheries Techniques. American Fisheries Society, Bethesda, MD.

Platts, W. S., Megahan W. F., and Minshall G. W. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Departmen of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-188. Ogden, UT.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191 Ottawa, Ontario.

Simberloff, D. S. 1976. Experimental zoogeography of islands: effects of island size. Ecology. 57:629-648.

Soper, K.A. 1983. Relationships between physical, chemical, and biological stream parameters and the stream-order classification system in montane streams of a New Mexico watershed. M.S. Thesis, New Mexico State University, Las Cruces.

U.S. Geological Survey. 1995. Water resources data New Mexico water year 1994. Albuquerque, NM.

Wetzel, R. 1983. Limnology, Second Edition, Saunders. New York, NY.

APPENDIX A
Stream Morphology and Habitat Data

Appendix Table 1. Percha Creek morphology.

Transect	Stream distance (m)	Width (m)	Slope	Depth-right (ft)	middle	left
1	61	3.59664	0.0125	0.55	0.4	0.25
2	91	1.524	0.0035	0.22	0.34	0.38
3	122	3.2004	0.0169	0.56		
4	152	5.0292	0.007	0.02	0.26	0.32
5	183	3.2004	0.0055	0.14	0.3	0.34
6	213	4.572	0.0099	0.52	0.54	0.64
7	244	1.6764	0.0056	0.26	0.24	0.28
8	267	4.1148	0.0156	0.54	0.6	0.46
9	279	3.3528	0.00175	0.54	0.28	0.3
10	310	7.1628	0.0326	1.88	1.74	1.26
11	335	1.6764	0.003412	0.34	0.56	0.68
12	366	2.286	0.0292	0.98	0.99	1.02
13	396	3.3528	0.0292	0.8	0.82	0.62
14	427	3.6576	0.0292	0.38	0.52	0.5
15	450	4.8768	0.0292	0.36	0.54	0.54
16	480	6.2484	0.0292	0.6	0.26	0.12
17	541	4.7244	0.0073	1.26	1.04	0.16
18	602	3.6576	0.0073	0.48	0.3	0.64
19 split channel	623	3.048	0.0073	0.26	0.52	0.38
20	left 654	2.4384	0.0073	0.16	0.36	0.34
21	right 652	2.4384	0.0073	0.2	0.22	0.48
22	main 668	4.7244	0.0073			
23	698	4.75488	0.0083	0.36	0.38	0.3
24	728	1.8288	0.0242	0.64	2.6	2.94
25	759	2.8956	0.0242	0.46	0.6	0.62
26	789	3.3528	0.0135	0.46	1	0.2
27	803	3.9624	0.0135	0.2	0.72	0.84
28	834	3.9624	0.0135	0.4	0.54	1
29	853	1.2192	0.0135	3.2	3.6	3.8
30	883	3.6576	0.00508	1.3	0.82	0.7
31	898	3.048	0.00508	0.46	0.94	0.92
32	909	2.7432	0.132449	0.24	0.36	0.26
33	939	2.1336	0.017678	0.2	0.28	0.38
34	969	1.2192	0.017678	0.1	0.18	0.12
35	990	1.2192	0.046838	0.06	0.22	0.3
36	1020	1.524	0.046838	0.4	0.68	0.6
37	1050	1.2192	0.046838	0.1	0.12	0.08
38	1080	1.6764	0.046838	0.38	0.28	0.28
39	1110	1.3716	0.016866	0.52	0.22	0.02
40	1140	1.524	0.011786	0.08	1.6	0.1
41	1170	0.9144	0.011786	0.22	0.4	0.5
42	1230	1.8288	0.011786	0.38	0.48	0.3

Appendix Table 2. Tierra Blanca Creek morphology.

Transect	Stream distance (m)	Width (m)	Slope	Depth-right middle left (ft)		
1	0	3.6576	0.036982	0.2	0.4	0.4
2	48	1.8288	0.036982	0.3	0.6	0.1
3	90	1.6764	0.009378	0.2	0.4	0.3
4	203	2.1336	0.022352	0.3	0.5	0.2
5	227	1.524	0.044196	0.3	0.4	0.4
6	256	1.8288	0.011176	0.3	0.7	0.2
7	360	1.524	0.011176	0.3	0.5	0.2
8	411	1.2192	0.084448	0.6	0.9	0.3
9	438	1.8288	0.026416	0.5	0.7	0.4
10	518	1.524	0.018796	0.3	0.5	0.5
11	528	2.1336	0.026416	0.1	0.3	0.3
12	680	1.8288	0.018796	0.2	0.5	0.3
13	729	1.8288	0.068646	0.2	0.5	0.4
14	917	1.8288	0.068646	0.3	0.5	0.3
15	938	2.1336	0.068646	0.5	0.6	0.4
16	960	2.7432	0.068646	0.4	0.6	0.3
17	1013	4.572	0.018835	0.3	0.5	0.3
18	1058	1.8288	0.011887	0.3	0.5	0.3
19	1089	1.6764	0.011887	0.2	0.5	0.2
20	1197	2.1336	0.011887	0.1	0.6	0.2
21	1321	1.6764	0.011887	0.3	0.5	0.2
22	1358	1.9812	0.011887	0.3	0.7	0.3
23	1422	1.6764	0.011887	0.3	0.5	0.2
24	1460	1.6764	0.011887	0.2	0.4	0.2
25	1488	1.8288	0.011887	0.2	0.4	0.2
26	1516	1.8288	0.011887	0.4	0.4	0.3
27	1554	2.1336	0.011887	0.4	0.5	0.3
28	1616	2.1336	0.011887	0.3	0.5	0.3
29	1688	2.4384	0.011887	0.3	0.4	0.2
30	1712	3.2004	0.044069	0.2	0.4	0.2
31	1754	1.8288	0.016476	0.2	0.3	2
32	1826	2.1336	0.016476	0.15	0.3	0.3
33	1989	1.8288	0.016476	0.3	0.5	0.3
34	2013	3.9624	0.016476	0.25	0.4	0.2

Appendix Table 3. Percha Creek habitat.

Stream distance (m)	Habitat type[a]	Substrate[b]	Embededness[c]	Stability[d]	Cover[e]
0-60	RI	2	4	2	3
60-95	RU	6	5	1	3
95-125	RI	2	4	2	3
125-189	RI	3	3	1	3
189-210	RI	2	3	2	3
210-225	RU	3	2	2	3
225-230	P	6	5	4	1
230-255	RU	3	1	3	3
255-282	RI	6	5	3	3
282-294	RU	6	5	3	3
294-305	P	6	5	4	3
305-333	RI	2	4	3	1
333-358	RU	3	2	2	3
358-383	RI	3	3	1	3
383-388	RU	3	3	2	3
388-398	RI	2	4	1	3
398-410	RU	5	5	1	3
410-417	P	3	4	1	1
417-446	RI	3	4	1	3
446-462	RU	6	5	2	3
462-473	RI	3	3	1	3
473-475	P	2	3	2	3
475-509	RI	6	2	2	3
509-517	P	5	5	2	3
517-540 split channel	RI	2	5	3	3
540-558 left	RI	3	5	3	1
558-561 left	P	5	3	3	1
561-577 left	RI	3	5	3	1
577-578 left	P	6	4	3	1
578-589 left	RI	1	4	2	3
540-573 right	RI	2	2	3	3
573-575 right	P	6	5	3	3
575-588 right	RI	2	4	3	3
588-604 main	RI	4	3	2	3
604-608	P	4	3	3	1
608-617	RU	4	3	2	1
617-623	P	6	5	4	3
623-632	RI	3	3	2	3
632-637	P	6	5	4	3
637-641	RI	1	2	4	3
641-644	P	6	5	4	3
644-652	RI	1	5	4	3
652-655	P	6	5	4	1
655-676	RI	1	5	4	1
676-700	RI	3	3	2	3
700-704	P	5	5	2	3

Table 3 (continued)

Stream distance (m)	Habitat type[a]	Substrate[b]	Embededness[c]	Stability[d]	Cover[e]
704-714	RU	4	3	3	1
714-720	P	6	5	2	3
720-741	RI	3	3	2	3
741-750	P	5	4	4	3
750-760	RI	3	4	2	3
760-766	P	5	5	4	3
766-771	RI	1	5	4	3
771-777	P	6	5	4	3
777-802	RU	6	5	2	3
802-827	RI	3	4	2	3
827-828	P	3	4	4	1
828-842	RI	3	3	4	1
842-846	P	6	5	4	1
846-853	RU	3	1	4	1
853-859	P	6	5	4	3
859-863	RI	1	5	4	3
863-866	P	6	5	4	3
866-873	RI	1	5	4	3
873-880	P	6	5	4	3
880-907	RI	1	5	4	3
907-912	P	6	5	4	3
912-927	RI	2	4	4	3
927-929	P	3	2	4	3
929-941	RI	1	4	4	3
941-943	P	3	3	4	3
943-971	RI	1	3	4	3
971-980	P	6	5	4	3
980-1070	RI	2	4	4	3
1070-1094	RU	3	1	4	3
1094-1106	RI	3	3	4	1
1106-1123	P	6	5	4	3
1123-1141	RI	3	3	4	1
1141-1143	P	3	2	4	1
1143-1150	RI	3	3	4	1
1150-1159	P	6	4	4	1
1159-1171	RI	1	4	4	1
1171-1176	P	6	4	4	3
1176-1204	RI	2	2	4	1
1204-1207	P	4	2	4	1
1207-1213	RI	4	2	4	1
1213-1215	P	6	5	4	1
1215-	RI	1	5	4	1

[a] RI=riffle, RU=run, P=pool

[b] 1=large boulder, 2=small boulder, 3=rubble, 4=gravel, 5=large fine sediment, 6=small fine sediment

[c] 1=>75%, 2=50-75%, 3=25-50%, 4=5-25%, 5=<5%

[d] 1=<25% exposed soil, 2=25-49%, 3=50-79%, 4=>80%

[e] 1=>50% no vegetation, 2=grass or forbes dominant, 3=shrubs or trees dominant

Appendix table 4. Tierra Blanca Creek Habitat

Stream distance (m)	Habitat type[a]	Substrate[b]	Embededness[c]	Stability[d]	Cover[e]
0-33	RU	4	3	4	1
33-35	P	6	5	4	1
35-44	RU	4	3	4	1
44-46	P	6	5	4	1
46-47	P	1	5	4	1
47-54	RI	4	3	4	1
54-58	RU	4	3	4	1
58-60	P	6	5	4	1
60-62	RI	4	3	4	1
62-66	P	6	5	4	1
66-69	RI	5	4	4	1
69-71	P	6	5	4	1
71-110	RI	1	5	4	1
110-145	RI	1	5	4	3
145-208	RU	4	2	4	3
208-249	RI	4	2	4	3
249-255	RU	4	2	4	3
255-257	P	4	5	4	3
257-268	RU	4	3	4	3
268-269	P	6	5	4	3
269-299	RI	1	5	4	3
299-348	RU	4	3	4	3
348-366	RI	4	3	4	3
366-367	P	6	5	4	3
367-400	RI	4	3	4	3
400-424	RU	4	2	4	3
424-430	RI	4	2	4	3
430-432	P	4	2	4	3
432-503	RI	4	3	4	3
503-519	RU	4	2	4	3
519-572	RI	4	2	4	3
572-589	RU	4	2	4	3
589-591	P	6	5	4	3
591-641	RI	4	2	4	1
641-850	RI	1	5	4	3
850-880	RI	1	5	4	3
880-935	RU	6	5	4	3
935-1077	RI	1	5	4	1
1077-1104	RU	5	5	4	3
1104-1108	RI	2	5	4	3
1108-1141	RU	3	4	4	3
1141-1169	RI	3	4	4	3
1169-1184	RU	4	3	4	3
1184-1202	RI	4	2	4	3
1202-1268	RU	6	5	4	3
1268-1313	RI	4	3	4	3
1313-1400	RU	3	3	4	3
1400-1427	RI	4	3	4	3
1427-1428	P	6	5	4	3

Tierra Blanca Creek (continued)

Stream distance (m)	Habitat type[a]	Substrate[b]	Embededness[c]	Stability[d]	Cover[e]
1428-1511	RI	4	3	4	3
1511-1517	RI	3	2	4	3
1517-1518	P	6	5	4	3
1518-1553	RI	4	2	4	3
1553-1731	RU	4	3	4	3
1731-1758	RI	1	5	4	3
1758-1761	P	3	2	4	3
1761-1790	RU	4	4	4	3
1790-1804	RI	1	5	4	3
1804-2013	RU	4	3	4	3

[a] RI=riffle, RU=run, P=pool

[b] 1=large boulder, 2=small boulder, 3=rubble, 4=gravel, 5=large fine sediment, 6=small fine sediment

[c] 1=>75%, 2=50-75%, 3=25-50%, 4=5-25%, 5=<5%

[d] 1=<25% exposed soil, 2=25-49%, 3=50-79%, 4=>80%

[e] 1=>50% no vegetation, 2=grass or forbes dominant, 3=shrubs or trees dominant

APPENDIX B

Appendix Table 1. Dissolved Oxygen and Temperature Data

TIME	DO[a]	TEMP[b]	SAT.[c]	SITE[d]	DATE
6:00	6.1	21.0	7.65	P	7/12/95
7:00	6.3	22.0	7.50	P	7/12/95
8:00	6.5	22.5	7.43	P	7/12/95
9:00	6.9	23.0	7.36	P	7/12/95
10:00	7.3	24.0	7.22	P	7/12/95
11:00	7.5	25.0	7.09	P	7/12/95
12:00	7.6	25.5	7.02	P	7/12/95
13:00	7.6	26.0	6.96	P	7/12/95
14:00	7.7	26.0	6.96	P	7/12/95
15:00	7.4	26.0	6.96	P	7/12/95
16:00	7.4	25.0	7.09	P	7/12/95
17:00	7.3	25.0	7.09	P	7/12/95
18:00	6.6	24.0	7.22	P	7/12/95
19:00	6.3	24.0	7.22	P	7/12/95
20:00	6.0	23.5	7.29	P	7/12/95
21:00	5.9	23.5	7.29	P	7/12/95
22:00	5.9	23.5	7.29	P	7/12/95
23:00	6.0	23.0	7.36	P	7/12/95
6:00	7.5	18.0	8.13	T	7/18/95
7:00	7.6	18.0	8.13	T	7/18/95
8:00	7.7	18.0	8.13	T	7/18/95
9:00	7.8	18.0	8.13	T	7/18/95
10:00	7.8	19.0	7.96	T	7/18/95
11:00	7.6	20.5	7.73	T	7/18/95
12:00	7.8	23.0	7.36	T	7/18/95
13:00	7.6	24.0	7.22	T	7/18/95
14:00	6.9	25.0	7.09	T	7/18/95
15:00	6.9	23.0	7.36	T	7/18/95
16:00	7.0	24.5	7.16	T	7/18/95
17:00	6.9	23.5	7.29	T	7/18/95
18:00	7.0	23.0	7.36	T	7/18/95
19:00	7.1	22.5	7.43	T	7/18/95
20:00	7.0	21.5	7.58	T	7/18/95
21:00	7.6	21.0	7.65	T	7/18/95
22:00	7.6	20.0	7.80	T	7/18/95
23:00	7.7	19.5	7.88	T	7/18/95
6:00	5.9	23.0	7.36	P	8/17/95
7:00	6.0	23.0	7.36	P	8/17/95
8:00	6.3	23.0	7.36	P	8/17/95
9:00	6.7	23.5	7.29	P	8/17/95
10:00	7.0	23.5	7.23	P	8/17/95
11:00	7.5	24.5	7.16	P	8/17/95
12:00	7.8	25.0	7.09	P	8/17/95
13:00	7.9	25.0	7.09	P	8/17/95

TIME	DO[a]	TEMP[b]	SAT.[c]	SITE[d]	DATE
13:00	7.9	25.0	7.09	P	8/17/95
14:00	7.5	24.5	7.16	P	8/17/95
15:00	8.1	24.0	7.22	P	8/17/95
16:00	7.8	24.0	7.22	P	8/17/95
17:00	7.3	24.0	7.22	P	8/17/95
18:00	8.0	24.0	7.22	P	8/17/95
19:00	5.8	25.0	7.09	P	8/17/95
20:00	5.5	25.5	7.02	P	8/17/95
21:00	5.6	25.5	7.02	P	8/17/95
22:00	5.4	25.0	7.09	P	8/17/95
23:00	5.7	25.0	7.09	P	8/17/95
6:00	7.4	18.5	8.05	T	8/21/95
7:00	7.4	18.5	8.05	T	8/21/95
8:00	7.6	18.5	8.05	T	8/21/95
9:00	7.8	18.5	8.05	T	8/21/95
10:00	7.6	19.5	7.80	T	8/21/95
11:00	7.6	20.5	7.88	T	8/21/95
12:00	7.7	21.5	7.73	T	8/21/95
13:00	7.8	23.0	7.58	T	8/21/95
14:00	7.2	23.0	7.36	T	8/21/95
15:00	7.1	23.5	7.22	T	8/21/95
16:00	7.0	23.5	7.29	T	8/21/95
17:00	7.1	24.0	7.29	T	8/21/95
18:00	7.1	24.0	7.22	T	8/21/95
19:00	6.8	23.0	7.36	T	8/21/95
20:00	6.7	22.5	7.43	T	8/21/95
21:00	6.7	21.0	7.65	T	8/21/95
22:00	6.9	21.0	7.65	T	8/21/95
23:00	7.0	20.5	7.73	T	8/21/95
6:00	9.0	11.0	9.47	T	10/7/95
7:00	8.9	11.0	9.47	T	10/7/95
8:00	9.0	11.0	9.47	T	10/7/95
9:00	9.5	11.0	9.47	T	10/7/95
10:00	10.2	12.0	9.25	T	10/7/95
11:00	11.0	14.0	8.85	T	10/7/95
12:00	11.0	15.0	8.66	T	10/7/95
13:00	10.4	18.0	8.13	T	10/7/95
14:00	8.9	19.5	7.88	T	10/7/95
15:00	8.5	19.0	7.96	T	10/7/95
16:00	7.2	19.0	7.96	T	10/7/95
17:00	6.9	19.0	7.96	T	10/7/95
18:00	6.6	18.0	8.13	T	10/7/95
19:00	6.5	17.5	8.21	T	10/7/95
20:00	6.6	17.0	8.30	T	10/7/95

Table 1 (continued)

TIME	DO[a]	TEMP[b]	SAT.[c]	SITE[d]	DATE
21:00	6.7	16.0	8.47	T	10/7/95
22:00	6.9	15.5	8.57	T	10/7/95
6:00	6.5	19.0	7.96	P	10/14/95
7:00	6.5	19.0	7.96	P	10/14/95
8:00	6.5	19.0	7.96	P	10/14/95
9:00	7.0	19.5	7.88	P	10/14/95
10:00	8.0	20.0	7.80	P	10/14/95
11:00	8.1	20.5	7.73	P	10/14/95
12:00	8.1	21.5	7.58	P	10/14/95
13:00	8.4	22.0	7.50	P	10/14/95
14:00	8.2	22.0	7.50	P	10/14/95
15:00	7.5	22.0	7.50	P	10/14/95
16:00	7.1	21.5	7.58	P	10/14/95
17:00	6.9	21.0	7.65	P	10/14/95
18:00	6.6	21.0	7.65	P	10/14/95
19:00	6.5	21.0	7.65	P	10/14/95
20:00	6.5	20.5	7.73	P	10/14/95
21:00	6.5	20.5	7.73	P	10/14/95
22:00	6.5	20.0	7.80	P	10/14/95
12:00	8.7	23.5	7.29	P	6/8/95
15:38	8.4	23.5	7.29	P	6/8/95
10:17	8.2	20.5	7.73	T	6/15/95
15:20	7.4	26.0	6.96	P	6/15/95
12:00	8.5	21.0	7.65	T	6/19/95
	9.4	25.5	7.02	P	6/19/95
6:15	6.5	13.0	10.52	P	4/30/95
1200	9.5	21.0	7.65	P	4/30/95
1700	7.7	22.0	7.50	P	4/30/95
1830	7.1	21.0	7.65	P	4/30/95
6:30	7.4	14.0	10.29	T	4/30/95
13:15	8	20.5	7.73	T	4/30/95
15:45	8	23.0	7.36	T	4/30/95
19:10	7.6	16.0	9.85	T	4/30/95

[a]Dissolved Oxygen (mg/l)
[b]Temperature (degrees C)
[c]100% saturation (mg/l)
[d]P=Percha Creek, T=Tierra Blanca Creek

APPENDIX C
Electrofishing Catch

Appendix Table 1. Longfin dace catch.

Reach 1:

Pass 1				Pass 2	Pass 3
Length (mm)	Weight (g)	Length(mm)	Weight (g)	Length (mm)	Length (mm)
29	0.2	34	0.2	65	62
21	0.1	61	1.9	69	71
59	2.0	27	0.1	17	60
30	0.3	56	1.8	57	30
56	1.8	33	0.4	63	29
70	3.4	46	0.9	31	30
36	2.0	61	1.8	24	21
66	2.7	65	2.9	26	29
54	1.4	65	2.6	32	25
56	1.6	57	1.3	19	61
56	1.9	65	3	65	56
69	2.8	56	2	22	71
68	3.1	65	2.6	29	31
43	0.6	56	1.5	62	32
40	0.5	70	3.4	36	61
60	2.3	65	2.8	25	70
60	2.4	67	3.5	64	28
58	2.0	68	2.9	49	28
48	0.9	39	0.5	64	32
37	0.5	20	0.2	26	58
25	0.1	29	0.3	26	29
40	0.7	32	0.3	69	21
30	0.2	31	0.3	29	32
19	0.1	30	0.3	32	70
53	1.1	54	2.5	39	56
		total catch 204		total catch 136	total catch 104

Table 1 (continued)
Reach 2:

Pass 1				Pass 2	Pass 3
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Length (mm)
60	2	71	3.4	29	59
76	4.3	25	0.1	29	56
69	2.4	17	0.1	72	27
64	2.3	24	0.1	78	31
57	1.7	36	0.6	31	91
71	3.2	30	0.3	65	19
61	2.1	57	2.2	32	76
71	3.1	54	1.8	66	28
59	2	67	3.3	33	64
76	4	30	0.3	24	24
28	0.1	70	3.2	63	60
36	0.4	64	3.1	64	34
64	2.7	66	3.5	21	26
62	2.6	34	0.3	59	66
72	4.5	52	1.7	22	34
34	0.3	30	0.3	21	20
24	0.2	32	0.2	52	20
21	0.1	50	1.4	55	29
28	0.1	72	4.7	24	69
22	0	34	0.4	24	35
72	4.1	32	0.3	66	56
24	0.1	70	4.1	29	16
72	4.4	65	3.2	68	29
66	2.9	42	0.7	20	21
66	3.2	30	0.3	34	25
		total catch 460		total catch 179	total catch 81

Table 1 (continued)

Reach 3:

Pass 1				Pass 2	Pass 3
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Length (mm)
56	1.8	34	0.1	42	76
32	0.1	66	2.4	73	30
60	2.2	27	0.1	35	26
61	2.6	59	1.7	41	64
22	0.1	33	0.1	56	26
26	0.1	66	1.1	40	31
26	0.1	65	2.7	29	35
60	2	30	0.1	32	31
27	0.3	39	0.3	42	47
58	2	51	1.3	29	26
24	0.1	21	0.1	43	61
25	0.1	62	1	64	61
69	3.9	64	2.6	25	40
72	4	55	1.6	25	32
62	2.9	36	0.5	25	22
29	0.1	22	0.1	29	56
31	0.1	35	0.3	55	23
29	0.2	74	6.1	20	34
60	2.1	62	2.3	69	20
46	1.3	64	1.8	22	60
65	2.6	31	0.2	52	24
66	3.1	39	0.5	26	60
16	0	29	0.1	56	22
27	0.2	61	2.2	28	32
24	0.1	31	0.1	57	26
		total catch 219		total catch 276	total catch 170

Pass #4 total catch 86

No lengths or weights taken

Appendix Table 2. Rio Grande sucker catch.

Reach 1:

Pass 1 Length (mm)	Pass 1 Weight (g)	Pass 2 Length(mm)	Pass 2 Weight (g)	Pass 3 Length (mm)	Pass 3 Weight (g)
89	6.9	49	0.5	42	0.8
46	1	102	8.1	49	1.1
45	0.9	101	8.2	94	8
		52	1.1	46	0.9
		45	0.5	55	1.5
		51	1.1	30	0.1
		39	0.6	34	0.2
		41	0.5	32	0.1
				41	0.5

Reach 2:

Pass 1 Length (mm)	Pass 1 Weight (g)	Length (mm)	Pass 2 Length (mm)	Pass 3 Length (mm)
47	0.9	89	132	106
57	1.6	114	48	122
110	10	76	42	81
111	8	51	101	41
94	8.2	56	86	88
89	7.9	57	41	138
49	1.4	61	55	100
135	22	44	119	95
111	11	115	44	96
42	0.7	95	54	46
39	0.5	102	86	64
41	0.7	104	135	98
48	1.4	94	91	24
91	7.2	105	36	135
110	12	102	44	112
108	10	41	42	111
46	0.9	42	102	52
106	9	44	115	56
41	0.7	46	42	98
54	1.9	102	95	62
44	0.8	91	90	98
121	16	51	95	54
55	1.7	76	90	105
106	9	62	125	52
77	3.8	33	91	42
total catch 50			total catch 37	53

Table 2 (continued)

Reach 3:

Pass 1		Pass 2	Pass 3	Pass 4
Length (mm)	Weight (g)	Length (mm)	Length (mm)	total catch 9
				No lengths or weights taken
143	29	37	46	
105 .		109	36	
41	0.6	115	29	
89	7.2	132	46	
101	9.9	115	105	
135	2.4	114	41	
89	8.3	86	92	
29	0.2	46	92	
30	0.1	35	46	
44	0.3	47	45	
42	0.6	40	45	
36	0.2	44	36	
47	0.4			
46	0.5			
111	13.5			
86	6.5			
111	14.5			
91	7.5			

Appendix D

Summary of Hours Used For Field and Laboratory Research

Study	Field	Laboratory	Total
Mapping, habitat, flow	42	.	42
Dissolved oxygen	52	.	52
Water chemistry	16	18	34
Artificial substrate	5	21	26
Natural substrate	3	23	26
Invertebrates	15	.	15
Fishes	16	.	16
Travel	47	.	47
Total	196	62	258

APPENDIX E
Budget

Salaries	$ 3793.50
Benefits	$ 619.79
Water chemistry at NMSU SWAT laboratory	$ 382.00
Hach Co., water chemistry supplies	$ 30.21
8 USGS 7.5 minute maps	$ 40.00
Overnight mail for invertebrate samples	$ 134.50
Total	$5000.00

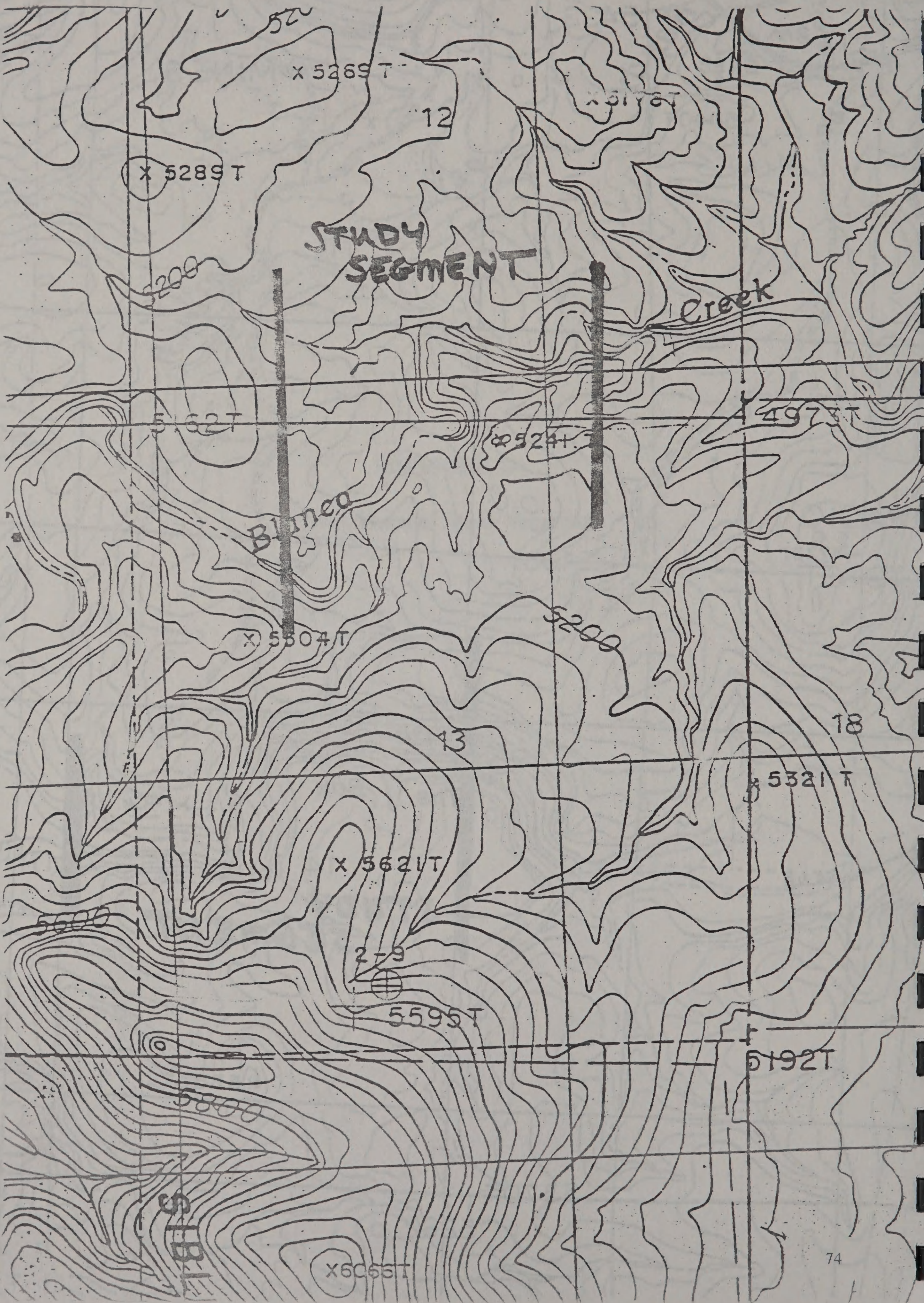
APPENDIX F
Species Observed

Common Name	Genus and species	Creek
FISH:		
Longfin Dace	*Agosia chrysogaster*	Percha
Rio Grande Sucker	*Catostomus plebeius*	Percha
AQUATIC INVERTEBRATES:	See appendix C	
AMPHIBIANS:		
Blacknecked garter snake	*Thamnopsis cyrtopsis*	Both
Canyon tree frog	*Hyla arnicolor*	Both
Whiptail lizard	*Cnemidophorus sp.*	Both
Texas horned lizard	*Phrynosoma cornutum*	Percha
BIRDS:		
Hummingbird	*unknown*	Both
Mourning doves	*Zenaida macroura*	Both
Western wood peewee	*Contopus sordidulus*	Both
Canyon wren	*Catherpes mexicanus*	Percha
Blue grosbeak	*Guiraca caerulea*	Percha
Olive sided fly catcher	*Contopus borealis*	Percha
Summer tananger	*Piranga rubra*	Percha
Yellow Warbler	*Dendroica petechia*	Percha
MAMMALS:		
Domestic cow	*Bos taurus*	Both
Squirrel	*Spermophilus variegatus*	Tierra Blanca
Deer (tracks)	*Odocoileus sp.*	Both
Raccoon (tracks)	*Procyon lotor*	Both
Coyote (tracks)	*Canis latrans*	Percha
WOODY PLANTS		
Arizona grape	*Vitus arizonica*	Both
Alder	*Alnus oblongifolia*	Both
Box elder	*Acer negundo*	Both
Cottonwood	*Populus grandidentata*	Both
Velvet ash	*Fraxinus pennsylvanica subspp. velutina*	Both
Willow	*Salix sp.*	Both
		Both
AQUATIC PLANTS		Both
Bulrush	*Scirpus sp.*	Both
Horsetail	*Equisetum sp.*	Both
Rushes	*Juncus sp.*	Both
Mimulus	*Mimulus sp.*	Both
Watercress	*Rorripa sp.*	Both
Spikerush	*Eleocharis sp.*	Both
Buckwheat	*Fagopyrum sp.*	Both
Smartweed	*Poligynum sp.*	Both
Snapdragon	*Anterrhinum sp.*	Both

APPENDIX G

USGS Maps of Study Segments


BM
5433
Ready
5488
MINES
5440T
MINES
Pay
Gulch
5745T
RADIO
TOWER
5723T
5403T
Percha
The
Box
PACK
5200
SAND
14
MINE
STUDY
SEGMENT
5385T
5370T
5262


X 5269 T
12
X 5289 T
STUDY SEGMENT
5200
Creek
4973 T
Blanco
X 5504 T
5200
13
18
5321 T
X 5621 T
2-9
5595 T
5192 T
5800
X 6066 T

APPENDIX H

Aquatic Macroinvertebrate Reports

Aquatic Benthic Macroinvertebrate Report

Report prepared for:
New Mexico State University
Fisheries & Wildlife Dept.
Knox Hall RM 132
Las Cruces, New Mexico 88003

Report Prepared by:

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17 October1996

INTRODUCTION

The goal of the Clean Water Act is to preserve and restore the biological integrity of aquatic resources. Monitoring is a tool we use to measure our management successes and failures and base our resource allocation adjustments on to meet this goal. Under the Clean Water Act federal agencies have the responsibility for monitoring water quality on federally managed lands.

Aquatic macroinvertebrates are an important component of aquatic ecosystems and have long been used to evaluate water quality. Among all the components of an aquatic ecosystem they are one of the best suited for monitoring and basing resource decisions on because they are numerous in almost all streams and lakes; they respond to changing environmental conditions, either natural or anthropogenic; they are readily collected and identified; they are not very mobile; they have sufficiently long life cycles to enable effects to be integrated over an annual period; and they provide a vital link in the food chain between primary producers (algae and macrophytes) and fish. They have also been shown to be a cost effective monitoring tool for evaluating the effects of management changes on stream and riparian condition.

This report provides a general assessment of the aquatic ecosystem based on the aquatic macroinvertebrate community. It was assumed the sampling area was representative of a larger area. The information provided should be integrated with other data collected in the watershed to gain a more complete understanding of pollution sources, impacts, and trends.

SAMPLING LOCATIONS

The information in this report is based on data collected at the sites listed below. Additional site location and management information for each site is shown in Table 1.

Station	Location
PERCHA-1	Percha Creek, Sierra County, New Mexico
PERCHA-2	Percha Creek, Sierra County, New Mexico
PERCHA-3	Percha Creek, Sierra County, New Mexico
PERCHA-4	Percha Creek, Sierra County, New Mexico
PERCHA-5	Percha Creek, Sierra County, New Mexico
PERCHA-6	Percha Creek, Sierra County, New Mexico
TIERRA-1	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-2	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-3	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-4	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-5	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-6	Tierra Blanca Creek, Sierra County, New Mexico

Table 1. Sampling locations. Distance is in miles, elevation is in feet. NP = data not provided.

Station	Latitude	Longitude	Stream order	Elev.	Distance to mouth	HUC	Ecoregion / Sub-ecoregion	Major landuse	Comments
PERCHA-1	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-2	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-3	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-4	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-5	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-6	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
TIERRA-1	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-2	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-3	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-4	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-5	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-6	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	

SAMPLING METHODS

Table 2. Sampling dates, methodology and comments.

Station	Date	Sample #	Sampling Method	Habitat Sampled	Sampling Area (m^2)	Comments
PERCHA-1	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand
PERCHA-2	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand/small boulders
PERCHA-3	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	coarse gravel
PERCHA-4	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand
PERCHA-5	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	small rocks
PERCHA-6	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	gravel
TIERRA-1	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel w/iron carbon
TIERRA-2	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel w/iron carbon
TIERRA-3	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	boulder habitat
TIERRA-4	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	bedrock
TIERRA-5	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	sand w/vegetation
TIERRA-6	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel

LABORATORY PROCESSING

Samples were identified at the BLM Aquatic Ecosystem Laboratory in Logan, Utah. Samples were processed following Elliott (88). Individual samples were first placed in a white enamel pan and observed under a magnifying glass. Large and less-numerous organisms were removed. The sample was then subsampled by dispersing it evenly within a No. 60 sieve (250 micron) located in a water-filled enamel pan. The sieve was then lifted out of the water and split into two equal parts with a spatula. This procedure was repeated until approximately 250 organisms remained in the sub-sample. Organisims were removed from the sub-sample using a stereoscope with 8-40X magnification. If less than 250 organisms were found in the subsample additional subsamples were taken. The amount of the original sample which was identified is shown in Table 3. The organisms were then identified and counted by well-qualified taxonomists. An effort was made to identify organisms to a consistent taxonomic level. Insects were primarily identified to genus, with the exception of Chironomidae which were identified to subfamily. Non-insect invertebrates were identified to various taxonomic levels depending on the availability of identification keys. Voucher specimens were retained for all unique taxa.

Table 3. Percentage of each sample that was identified and any laboratory comments.

Station	Date	Sample #	Field split %	Lab split %	% id'd	Comments
PERCHA-1	07/12/95	1 of 1	None	None	100	None
PERCHA-2	07/12/95	1 of 1	None	None	100	None
PERCHA-3	07/12/95	1 of 1	None	50	50	None
PERCHA-4	07/12/95	1 of 1	None	None	100	None
PERCHA-5	07/12/95	1 of 1	None	None	100	None
PERCHA-6	07/12/95	1 of 1	None	None	100	None
TIERRA-1	06/19/95	1 of 1	None	None	100	None
TIERRA-2	06/19/95	1 of 1	None	None	100	None
TIERRA-3	06/19/95	1 of 1	None	50	50	None
TIERRA-4	06/19/95	1 of 1	None	None	100	None
TIERRA-5	06/19/95	1 of 1	None	None	100	None

Table 3, continued.

Station	Date	Sample #	Field split	Lab split	% id'd	Comments
TIERRA-6	06/19/95	1 of 1	None	None	100	None

DATA ANALYSIS

Interpretation of the health and integrity of the aquatic ecosystem was based on a number of aquatic macroinvertebrate indices and life history characteristics of individual taxa and physical habitat and water chemistry data (if collected). The indices used were those recommended for use by the U.S. Environmental Protection Agency (82) and others (43, 44, 45, 50,53, 79). These indices should be compared to those calculated for other sites, either impacted or non-impacted, and be used to document changes over time at the same site. Abundance data is shown as the number per square meter (#/m^2) for quantitative samples and the number per sample for qualitative samples.

Community summary statistics

<u>Richness and enumeration measures</u>
Taxa richness - Richness is a component and estimate of community structure and stream health based on the number of distinct taxa. Taxa richness normally decreases with decreasing water quality (50). In some situations organic enrichment resulta in an increase in the number of taxa, including EPT taxa (82).

Abundance - The abundance of aquatic macroinvertebrates is an indicator of habitat availability, suitability and fish food abundance. It may be reduced or increased depending on the type of pollution.

EPT - A summary of the taxa richness within the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are considered to be sensitive to pollution. EPT generally increases with increasing water quality (53).

Family level measures - All families are separated and counted. The number and diversity of families normally decreases with decreasing water quality (50).

<u>Diversity measures</u>
Ecological diversity is a measure of community structure defined by the relationship between the number of distinct taxa (S) and their relative abundances (n). Washington (83) reviewed the use of diversity indices in aquatic ecosystems and suggested the use of Simpson's D, however, Shannon's index is widely used and dbar has been used by the EPA (85) and the USFS (84).

Margalef's index - Based on the presumed linear relationship between the number of species and the logarithm of the number of individuals. It is seldom used today (83) and is included for comparison to historical data where this index was used. It is calculated as S-1/ln(n).

Menhinick's index - This index is correlated to sample size and is not widely used in aquatic ecology (83) and is included primarily for comparison to historical data where this index was used. It is calculated as S/SQRT(n).

Shannon's H - Shannon's H' (47) is widely used in community ecology. It is a measure of the average degree of uncertainty in predicting what species an individual chosen at random from a collection of species and individuals will belong. This average uncertainty increases as the number of species increases and as the distribution of individuals among taxa becomes even. The higher the number the greater the diversity. However, small cold streams have naturally low diversity and for this reason some have criticized the use of H'.

Dbar - Dbar has been used by the EPA (85) and the USFS (84). Values range from 0 to 3.32 log N. It was calculated based on the machine formula presented by Lloyd et al. (86).

Simpson - Simpson's (46) diversity index is defined as the probability of picking two individuals that are of the same group. Abundant taxa receive more weight. Values range from 0-1; the higher the number the greater the diversity.

Evenness - Evenness is a measure of the distribution of taxa within a community. The evenness index used in this report is that recommended by Ludwig and Reynolds (87). Values range from 0-1 and approach zero as a single taxon becomes more dominant.

Biotic indices

Biotic indices make use of the indicator taxa concept. Taxa are assigned water quality tolerance values (TV) or quotients (TQ) based on their tolerance to pollution. The most common biotic indices in use in the United States are the modified Hilsenhoff Biotic Index and the USFS Biotic Condition Index.

Modified Hilsenhoff Biotic Index - This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It is best at detecting organic pollution. All taxa are assigned a TV from 0 - for taxa known to occur only in high quality water, to 10 - for taxa known to occur in severely polluted waters. TV values came from Hilsenhoff (43, 44) and Bode et al. (45). The MHBI is calculated by multiplying the TV for each taxon by the taxon abundance, summing the products, and dividing by the number total sample abundance. Waters with values 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted.

USFS Community tolerant quotient/biotic condition index -
Unimpacted benthic aquatic macroinvertebrate community structure (CTQp) is predicted based on total alkalinity, sulfate, substrate size, and stream gradient. The actual benthic aquatic macroinvertebrate community structure (CTQd) corrected for taxa dominance is then divided by the CTQp and multiplied by 1030 to determine the biotic condition index (BCI). All taxa are assigned a TQ from 0- pollution intolerant, to 108 - pollution tolerant (84). Waters having a BCIs >90 are considered excellent, 80-90 good, 72-79 fair, and <72 poor. This index has been widely used by the USFS and BLM in the western United States.

Functional feeding group classification

Shredders - Shredders utilize coarse particulate organic matter (CPOM). They are sensitive to changes in riparian vegetation and can be good indicators of the presence of toxicants. Xylophages are shredders which eat wood and are typically long lived.

Scrapers - Scrapers feed on periphyton (attached algae and associated material). Scraper populations increase with increasing abundance of diatoms and decrease as filamentous algae, mosses, and vascular plants increase. Scrapers decrease in relative abundance in response to sedimentation and organic pollution.

Collector-filterers - Collector-filterers feed on suspended fine particulate organic matter (FPOM). Collector-filterers are sensitive to toxicants attached to suspended particles.

Collector-gatherers - Collector-gatherers feed on deposited fine particulate organic matter. Collector-gatherers are sensitive to deposited toxicants.

Predators - Predators feed on living animal tissue.

The primary difference between the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols (RBP) II and III is RBP II invertebrates are identified in the field to family and for RBP III invertebrates are identified in the laboratory to genus or species (82). The degree of impairment at a site is based on the relative differences observed for eight primary metrics calculated between a sampling site and a control or reference site. In many cases reference data are unavailable, nevertheless these metrics can be used to evaluate general water quality and they can be used when reference data becomes available (Table 6).

The eight metrics used in RBP II and III are:

1. Species richness

2. Modified Hilsenhoff Biotic Index

3. Ratio of scraper to collector-filterer + scraper functional feeding groups - This ratio reflects the riffle/run community food base and can provide insight into the nature of potential disturbance factors. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an abundance of a particular food source. The predominant feeding strategy reflects the type of impact detected. Scrapers increase with increased abundance of diatoms and decrease as filamentous algae and aquatic mosses increase. Filamentous algae and aquatic mosses provide good attachment sites for collector-filterers and the organic enrichment often responsible for high abundance of filamentous algae provides FPOM utilized by filterers. Filterer-collectors are also sensitive to toxicants bound to fine particles and may decrease in abundance when exposed to such sources. The scraper:collector-filterer + scrapers ratio may not be a good indicator of organic enrichment if adsorbing toxicants are present.

4. Ratio of EPT to Chironomidae + EPT abundances - This ratio evaluates the relative abundance of these indicator groups as a measure of community balance. Good biotic condition is reflected in communities having a fairly even distribution among all four major taxonomic groups and with substantial representation in the sensitive groups Ephemeroptera, Plecoptera, and Trichoptera. Skewed populations having a disproportionately high number of the generally tolerant Chironomidae relative to the more sensitive groups may indicate environmental stress (82). In general, Chironomids tend to become increasingly dominant along a gradient of increasing enrichment or heavy metal concentration.

5. Percent contribution of dominant taxon - A community dominated by few taxa indicates environmental stress (82). Values range from 0-1. Lower values indicate a more balanced community balance and better water quality.

6. EPT richness - The total number of taxa within the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are considered to be sensitive to pollution. EPT generally increases with increasing water quality (53).

7. Ratio of shredder functional feeding group and total number of individuals collected - This metric evaluates potential impairment as indicated by the relative presence of shredders. Shredders are sensitive to riparian impacts and are good indicators of the availability of CPOM and toxic effects. The degree of toxicant effects on shredders versus filterers depends on the the toxicant, the size of the particle it is attached to, and its organic particle adsorption efficiency. Toxicants of a terrestrial source (e.g., pesticides, herbicides) accumulate on CPOM prior to leaf fall and may have a substantial effect on shredders.

Water quality impairment indicator groups

The presence, absence or relative dominance of a particular taxon or group of taxa can provide information on the relative water quality at a site. Taxa were labeled as pollution intolerant if they are known to occur primarily in unpolluted waters. Pollution tolerant taxa are those known to be tolerant of fine sediment, high water temperatures, or high organic loads. Tolerance values are shown in the life history table.

Pollution Intolerant taxa

Intolerant mayflies - Mayflies are common in most waters and several taxa are ultra sensitive to fine sediment, low dissolved oxygen, or high water temperatures. The major pollution intolerant famlies are Ephemerellidae, Heptageniidae, and some Baetidae.

Intolerant stoneflies - Most stoneflies are sensitive to changes in substrate composition, water temperature, and retention of coarse organic matter (CPOM, leaves, twigs). Pteronarcys is a common stonefly which lives longer than 1 year and is sensitive to changes in substrate and CPOM retention. Nemouridae are common shredder stoneflies that are intolerant of organic loading and fine sediment.

Intolerant caddisflies - Intolerant caddisflies include the families Arctopsychidae, Glossosomatidae, Philopotamidae, Psychomyiidae, and many Rhyacophilidae and Limnephilidae. These families are widely distributed in most unpolluted waters and prefer coarse substrates.

Corydalidae - Helgramites are long lived and sensitive to excessive fine sediment deposition. Their presence indicates stable good habitat conditions.

Intolerant dipterans - Non-chironomidae dipterans which are intolerant of habitat degradation. Taxa include Blephariceridae, Deuterophebiidae, Dixidae, Pelecorhynchidae.

Intolerant Chironomidae - Includes members of the subfamilies Prodiamesinae, Podonominae, and Diamesinae.

Intolerant molluscs - Hydrobiidae snails and Unionidae mussels have moderate pollution tolerances.

Pollution Tolerant taxon

Tolerant mayflies - In contrast to many mayflies these taxa are tolerant of warmer water, and higher fine sediment orgainc loads. Taxa include Tricorythodes, Hexagenia, Caenis, Acentrella, and Baetis tricaudatis.

Tolerant caddisflies - Hydropsyche, Cheumatopsyche, hydroptilids, Helicopsyche, Hesperophylax, Limnephilus, and some Leptocerids are tolerant of warmer water and higher fine sediment levels.

Tolerant beetles - Agabetus, Carabidae, Helichus, Haliplidae, and many psephenids and elmids are tolerant of warmer water, and higher levels of fine sediment and nutrient enrichment.

Tolerant odonates - Most odonates are tolerant of warm water, high nutrients, fine sediment, and dense communities of filamentous algae.

Tolerant dipterans - Antocha, Athericidae, Ceraptopogonidae, Culicidae, Dolichopodidae, Empididae, Ephydridae, Muscidae, Psychodidae, Stratimoyidae, and Tabanidae are families which are typically abundant in waters with low habitat integrity.

Tolerant Chironomidae - The sub-families Chironominae, Orthocladiinae, and

Tanypodinae are tolerant of fine sediment and organic enrichment.

Simuliidae - Abundant in all lotic waters, but excessively high numbers (>40% total abundance) may indicate nutrient enrichment.

Tolerant amphipods - Common in springs and downstream of dams, numerous amphipods in other stream types may indicate nutrient enrichment.

Tolerant snails - Most pulmonate snails are tolerant of warm water and fine sediment.

Oligochaeta - Highly tolerant of fine sediment.

Leeches - Tolerant of fine sediment and organic enrichment.

Voltinism

Voltinism refers to life cycle length. Taxa requiring more than one year to complete their life cycle are more dependent on stable conditions than short lived taxa. A community with very few taxa with life cycles longer than eight months might indicate instability or a recent pollution event. Taxa were classified as being multivoltine, (multiple generations per year), univoltine, (a single generation per year), or semivoltine, (life cycles last more than one year). Classification was based on published and unpublished sources.

Community summary statistics. EPT = Insect orders, Ephemeroptera, Plecoptera, Trichoptera. MHBI = Modified Hilsenhoff Biotic Index. Abundance data is number per meter squared for quantitative samples and number per sample for qualitative samples. NC = Not calculated. * = unable to calculate.

Richness and enumeration measures

Station	Date	Total richness	Total abundance	EPT richness	EPT abundance	# of families	Dominant family	Dom. Family abundance	Dom. Family % contribution
PERCHA-1	07/12/95	13	258	4	97	12	Physidae	54	20.80
PERCHA-2	07/12/95	10	172	4	86	8	Hydropsychidae	43	25.00
PERCHA-3	07/12/95	21	8398	8	7677	17	Hydropsychidae	7333	87.30
PERCHA-4	07/12/95	4	108	2	43	4	Simuliidae	54	50.00
PERCHA-5	07/12/95	6	194	3	129	5	Tricorythidae	65	33.30
PERCHA-6	07/12/95	4	86	3	75	3	Hydropsychidae	43	50.00
TIERRA-1	06/19/95	7	699	3	290	7	Simuliidae	215	30.80
TIERRA-2	06/19/95	8	280	2	140	8	Hydropsychidae	108	38.50
TIERRA-3	06/19/95	5	12258	2	796	5	Simuliidae	11419	93.20
TIERRA-4	06/19/95	14	763	5	355	11	Baetidae	194	25.40
TIERRA-5	06/19/95	19	3022	3	731	14	Simuliidae	817	27.00
TIERRA-6	06/19/95	11	753	4	312	9	Naucoridae	226	30.00
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Mean		10	2249	4	894	9		1714	42.61

Community summary statistics, continued.

Diversity indices

Station	Date	Shannon diversity	Dbar diversity	Simpson diversity	Margalef diversity	Menhinick diversity	evenness
PERCHA-1	07/12/95	2.395	3.455	0.104	2.161	0.809	0.863
PERCHA-2	07/12/95	2.155	3.108	0.128	1.748	0.762	0.895
PERCHA-3	07/12/95	0.712	1.027	0.760	2.213	0.229	0.304
PERCHA-4	07/12/95	1.168	1.685	0.354	0.641	0.386	0.823
PERCHA-5	07/12/95	1.600	2.308	0.224	0.950	0.431	0.875
PERCHA-6	07/12/95	1.213	1.750	0.336	0.673	0.431	0.836
TIERRA-1	06/19/95	1.523	2.197	0.250	0.916	0.265	0.839
TIERRA-2	06/19/95	1.766	2.548	0.216	1.243	0.478	0.748
TIERRA-3	06/19/95	0.297	0.429	0.871	0.425	0.045	0.429
TIERRA-4	06/19/95	2.180	3.145	0.143	1.958	0.507	0.761
TIERRA-5	06/19/95	2.195	3.167	0.156	2.246	0.346	0.679
TIERRA-6	06/19/95	1.809	2.609	0.210	1.510	0.401	0.735
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Mean		1.584	2.286	0.313	1.390	0.424	0.732

Community summary statistics, continued.

Biotic indices

Station	Date	MHBI	Indication	United States Forest Service Biotic Condition Index CTQp	CTQa	CTQd	BCI	Indication
PERCHA-1	07/12/95	4.33	Moderate organic enrichment	53	85	88	60	Poor
PERCHA-2	07/12/95	4.87	Moderate organic enrichment	53	103	104	51	Poor
PERCHA-3	07/12/95	4.05	Moderate organic enrichment	53	95	95	56	Poor
PERCHA-4	07/12/95	4.90	Moderate organic enrichment	53	99	101	52	Poor
PERCHA-5	07/12/95	4.50	Moderate organic enrichment	53	100	100	53	Poor
PERCHA-6	07/12/95	4.62	Moderate organic enrichment	53	99	101	53	Poor
TIERRA-1	06/19/95	5.34	Moderate organic enrichment	53	100	100	53	Poor
TIERRA-2	06/19/95	4.04	Moderate organic enrichment	53	100	100	53	Poor
TIERRA-3	06/19/95	5.03	Moderate organic enrichment	53	90	93	57	Poor
TIERRA-4	06/19/95	4.69	Moderate organic enrichment	53	87	89	59	Poor
TIERRA-5	06/19/95	5.11	Moderate organic enrichment	53	98	97	55	Poor
TIERRA-6	06/19/95	3.69	Slight organic enrichment	53	95	95	56	Poor
Mean		4.60		53	96	97	55	

Community summary statistics, continued.

Taxa pollution tolerance summary.

		Intolerant taxa				Tolerant taxa			
Station	Date	# of taxa	%	sample abundance	%	# of taxa	%	sample abundance	%
PERCHA-1	07/12/95	1	7.7	11	4.3	4	30.8	97	37.6
PERCHA-2	07/12/95	0	0.0	0	0.0	6	60.0	108	62.8
PERCHA-3	07/12/95	2	9.5	118	1.4	9	42.9	7871	93.7
PERCHA-4	07/12/95	0	0.0	0	0.0	2	50.0	43	39.8
PERCHA-5	07/12/95	0	0.0	0	0.0	3	50.0	129	66.5
PERCHA-6	07/12/95	0	0.0	0	0.0	3	75.0	75	87.2
TIERRA-1	06/19/95	0	0.0	0	0.0	4	57.1	462	66.1
TIERRA-2	06/19/95	0	0.0	0	0.0	3	37.5	151	53.9
TIERRA-3	06/19/95	0	0.0	0	0.0	2	40.0	796	6.5
TIERRA-4	06/19/95	1	7.1	11	1.4	6	42.9	527	69.1
TIERRA-5	06/19/95	0	0.0	0	0.0	7	36.8	1011	33.5
TIERRA-6	06/19/95	0	0.0	0	0.0	5	45.5	333	44.2
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Mean		0	3.3	12	0.5	5	44.3	967	43.0

Taxa richness by functional feeding group; number of taxa per meter squared for quantitative samples and number of taxa per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Shredders	Scrapers	Collector filterers	Collector gatherers	Predators	Unknown
PERCHA-1	07/12/95	2 (15)	0 (0)	2 (15)	3 (23)	6 (46)	0 (0)
PERCHA-2	07/12/95	1 (10)	1 (10)	2 (20)	4 (40)	2 (20)	0 (0)
PERCHA-3	07/12/95	3 (14)	0 (0)	3 (14)	7 (33)	7 (33)	1 (5)
PERCHA-4	07/12/95	0 (0)	0 (0)	3 (75)	1 (25)	0 (0)	0 (0)
PERCHA-5	07/12/95	1 (17)	0 (0)	3 (50)	1 (17)	1 (17)	0 (0)
PERCHA-6	07/12/95	1 (25)	0 (0)	1 (25)	2 (50)	0 (0)	0 (0)
TIERRA-1	06/19/95	1 (14)	0 (0)	2 (29)	2 (29)	1 (14)	1 (14)
TIERRA-2	06/19/95	0 (0)	0 (0)	2 (25)	2 (25)	3 (38)	1 (13)
TIERRA-3	06/19/95	0 (0)	1 (20)	2 (40)	1 (20)	1 (20)	0 (0)
TIERRA-4	06/19/95	2 (14)	0 (0)	2 (14)	5 (36)	4 (29)	1 (7)
TIERRA-5	06/19/95	1 (5)	0 (0)	3 (16)	8 (42)	6 (32)	1 (5)
TIERRA-6	06/19/95	2 (18)	0 (0)	2 (18)	3 (27)	3 (27)	1 (9)
Mean		1 (11)	0 (2)	2 (22)	3 (32)	3 (28)	1 (5)

Invertebrate abundance by functional feeding group; abundance per meter squared for quantitative samples and abundance per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Shredders	Scrapers	Collector filterers	Collector gatherers	Predators	Unknown
PERCHA-1	07/12/95	43 (17)	0 (0)	54 (21)	86 (33)	75 (29)	0 (0)
PERCHA-2	07/12/95	32 (19)	11 (6)	43 (25)	43 (25)	43 (25)	0 (0)
PERCHA-3	07/12/95	86 (1)	0 (0)	7441 (89)	645 (8)	204 (2)	22 (0)
PERCHA-4	07/12/95	0 (0)	0 (0)	97 (90)	11 (10)	0 (0)	0 (0)
PERCHA-5	07/12/95	43 (22)	0 (0)	75 (39)	65 (34)	11 (6)	0 (0)
PERCHA-6	07/12/95	11 (13)	0 (0)	43 (50)	32 (37)	0 (0)	0 (0)
TIERRA-1	06/19/95	22 (3)	0 (0)	280 (40)	376 (54)	11 (2)	11 (2)
TIERRA-2	06/19/95	0 (0)	0 (0)	118 (42)	43 (15)	75 (27)	43 (15)
TIERRA-3	06/19/95	0 (0)	22 (0)	11570 (94)	645 (5)	22 (0)	0 (0)
TIERRA-4	06/19/95	22 (3)	0 (0)	172 (23)	366 (48)	161 (21)	43 (6)
TIERRA-5	06/19/95	22 (1)	0 (0)	860 (28)	1075 (36)	688 (23)	376 (12)
TIERRA-6	06/19/95	22 (3)	0 (0)	194 (26)	247 (33)	247 (33)	43 (6)
Mean		25 (1)	3 (0)	1746 (78)	303 (13)	128 (6)	45 (2)

U.S. Environmetal Protection Agency Rapid Bioassessment Protocol III metric values. MHBI = Modified Hilsenhoff Biotic Index, SC = scraper, CF = collecter-filterer, EPT = Insect orders, Ephemeroptera, Plecoptera, Trichoptera. Abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples. NC = Not calculated. * = unable to calculate.

Station	Date	Total richness	MHBI	SC:CF ratio	EPT: Chironomidae ratio	% contribution dominant taxon	EPT richness	Riffle sample SH:abundance (% shredders) ratio
PERCHA-1	07/12/95	13	4.33	0.000	1.000	20.800	4	16.7
PERCHA-2	07/12/95	10	4.87	0.200	0.800	25.000	4	18.6
PERCHA-3	07/12/95	21	4.05	0.000	0.965	87.300	8	1.0
PERCHA-4	07/12/95	4	4.90	0.000	0.800	50.000	2	0.0
PERCHA-5	07/12/95	6	4.50	0.000	1.000	33.300	3	22.2
PERCHA-6	07/12/95	4	4.62	0.000	1.000	50.000	3	12.8
TIERRA-1	06/19/95	7	5.34	0.000	0.628	30.800	3	3.1
TIERRA-2	06/19/95	8	4.04	0.000	0.929	38.500	2	0.0
TIERRA-3	06/19/95	5	5.03	0.002	1.000	93.200	2	0.0
TIERRA-4	06/19/95	14	4.69	0.000	0.647	25.400	5	2.9
TIERRA-5	06/19/95	19	5.11	0.000	0.701	27.000	3	0.7
TIERRA-6	06/19/95	11	3.69	0.000	0.906	30.000	4	2.9
Mean		10	4.60	0.017	0.865	42.608	4	1.1

Voltinism classification. Taxa richness within each group; presented as the number of taxa per meter squared for quantitative samples and number of taxa per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Multivoltine	Univoltine	Semivoltine	Unknown
PERCHA-1	07/12/95	2 (15)	7 (54)	3 (23)	1 (8)
PERCHA-2	07/12/95	2 (20)	8 (80)	0 (0)	0 (0)
PERCHA-3	07/12/95	5 (24)	10 (48)	5 (24)	1 (5)
PERCHA-4	07/12/95	1 (25)	3 (75)	0 (0)	0 (0)
PERCHA-5	07/12/95	2 (33)	3 (50)	1 (17)	0 (0)
PERCHA-6	07/12/95	0 (0)	3 (75)	1 (25)	0 (0)
TIERRA-1	06/19/95	3 (43)	4 (57)	0 (0)	0 (0)
TIERRA-2	06/19/95	3 (38)	5 (63)	0 (0)	0 (0)
TIERRA-3	06/19/95	2 (40)	3 (60)	0 (0)	0 (0)
TIERRA-4	06/19/95	2 (14)	12 (86)	0 (0)	0 (0)
TIERRA-5	06/19/95	3 (16)	10 (53)	4 (21)	2 (11)
TIERRA-6	06/19/95	3 (27)	8 (73)	0 (0)	0 (0)
		------ ----	------ ----	------ ----	------ ----
Mean		2 (23)	6 (62)	1 (11)	0 (3)

Voltinism classification. Invertebrate abundance within each group; presented as abundance per meter squared for quantitative samples and abundance per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Multivoltine	Univoltine	Semivoltine	Unknown
PERCHA-1	07/12/95	54 (21)	118 (46)	32 (12)	54 (21)
PERCHA-2	07/12/95	65 (38)	108 (63)	0 (0)	0 (0)
PERCHA-3	07/12/95	280 (3)	7871 (94)	226 (3)	22 (0)
PERCHA-4	07/12/95	54 (50)	54 (50)	0 (0)	0 (0)
PERCHA-5	07/12/95	22 (11)	129 (66)	43 (22)	0 (0)
PERCHA-6	07/12/95	0 (0)	75 (87)	11 (13)	0 (0)
TIERRA-1	06/19/95	441 (63)	258 (37)	0 (0)	0 (0)
TIERRA-2	06/19/95	54 (19)	226 (81)	0 (0)	0 (0)
TIERRA-3	06/19/95	12065 (98)	194 (2)	0 (0)	0 (0)
TIERRA-4	06/19/95	247 (32)	516 (68)	0 (0)	0 (0)
TIERRA-5	06/19/95	1441 (48)	1043 (35)	516 (17)	22 (1)
TIERRA-6	06/19/95	344 (46)	409 (54)	0 (0)	0 (0)
		------ ----	------ ----	------ ----	------ ----
Mean		1256 (56)	917 (41)	69 (3)	8 (0)

Taxonomic list for all samples collected in the New Mexico State University.

Order	Family	Subfamily	Genus/species	Relative occurrence
Phylum: Annelida				
Class: Oligochaeta				
Tubificida	Tubificidae			very rare
Phylum: Arthropoda				
Class: Arachnoidea				
Hydracarina				common
Class: Insecta				
Coleoptera	Curculionidae			very rare
Coleoptera	Dryopidae		Helichus	common
Coleoptera	Dytiscidae		Deronecetes	common
Coleoptera	Elmidae		Heterelmis	very rare
Coleoptera	Elmidae		Microcylloepus	common
Coleoptera	Hydrophilidae			very rare
Coleoptera	Hydrophilidae		Tropisternus	very rare
Diptera	Ceratopogonidae			very rare
Diptera	Chironomidae			rare
Diptera	Chironomidae	Chironominae		rare
Diptera	Chironomidae	Orthocladiinae		abundant
Diptera	Chironomidae	Tanypodinae		common
Diptera	Simuliidae			very rare
Diptera	Simuliidae		Simulium	very abundant
Diptera	Stratiomyidae		Caloparyphus	abundant
Diptera	Stratiomyidae		Euparyphus	common
Diptera	Tabanidae		Tabanus	common
Diptera	Thaumaleidae			very rare
Diptera	Tipulidae			very rare
Ephemeroptera	Baetidae		Baetis	abundant
Ephemeroptera	Tricorythidae			very rare
Ephemeroptera	Tricorythidae		Tricorythodes	abundant
Hemiptera	Belostomatidae			very rare
Hemiptera	Belostomatidae		Abedus	very rare
Hemiptera	Belostomatidae		Belastoma	very rare
Hemiptera	Corixidae		Hesperocorixa	very rare
Hemiptera	Gerridae			rare
Hemiptera	Naucoridae		Ambrysus	abundant
Hemiptera	Veliidae			very rare
Lepidoptera	Pyralidae		Petrophila	very rare
Megaloptera	Corydalidae		Corydalus	very rare
Odonata	Calopterygidae		Hetaerina	very rare
Trichoptera	Hydropsychidae			very rare
Trichoptera	Hydropsychidae		Cheumatopsyche	common
Trichoptera	Hydropsychidae		Hydropsyche	very abundant
Trichoptera	Hydroptilidae			common
Trichoptera	Hydroptilidae		Hydroptila	common
Trichoptera	Hydroptilidae		Ochrotrichia	very rare
Trichoptera	Leptoceridae		Oecetis	rare
Trichoptera	Philopotamidae		Chimarra	very rare
Trichoptera	Polycentropodidae			very rare
Trichoptera	Rhyacophilidae		Rhyacophila	rare
Phylum: Mollusca				
Class: Gastropoda				
Basommatophora	Physidae		Physella	common
Phylum: Platyhelminthes				
Class: Turbellaria				
Tricladida	Planariidae			very rare

A total of 46 taxa were collected in 12 samples. Relative occurrence was determined by the presence or absence of taxa within individual samples. Very abundant = >75%, abundant = 50-74%, common = 30-49%, rare = 10-24%, very rare <10% of the samples contained that particular taxon.

Relative contribution of taxon collected from all samples collected in the New Mexico State University. Abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples. ***.* = <0.1%.

Taxon	Average abundance	Average percent	Cumulative percent	
Simulium	1057	46.8	46.8	
Hydropsyche	668	29.5	76.3	
Baetis	163	7.2	83.5	
Orthocladiinae	65	2.9	86.3	
Caloparyphus	45	2.0	88.3	
				Five dominant taxa
Ambrysus	43	1.9	90.2	
Hetaerina	39	1.7	91.9	
Microcylloepus	26	1.1	93.1	
Tricorythodes	18	0.8	93.9	
Hydracarina	13	0.6	94.4	
				Ten dominant taxa
Euparyphus	13	0.6	95.0	
Tanypodinae	12	0.5	95.5	
Chimarra	9	0.4	95.9	
Ochrotrichia	9	0.4	96.3	
Hydroptilidae	8	0.4	96.6	
Physella	7	0.3	96.9	
Cheumatopsyche	6	0.3	97.2	
Helichus	6	0.3	97.5	
Tabanus	5	0.2	97.7	
Hydroptila	5	0.2	98.0	
Chironomidae	5	0.2	98.2	
Deronecetes	4	0.2	98.4	
Chironominae	4	0.2	98.6	
Simuliidae	3	0.1	98.7	
Curculionidae	2	0.1	98.8	
Petrophila	2	0.1	98.9	
Ceratopogonidae	2	0.1	99.0	
Belostomatidae	2	0.1	99.0	
Hydropsychidae	2	0.1	99.1	
Heterelmis	2	0.1	99.2	
Tricorythidae	2	0.1	99.3	
Gerridae	2	0.1	99.4	
Rhyacophila	2	0.1	99.4	
Oecetis	2	0.1	99.5	
Abedus	1	***.*	99.6	
Planariidae	1	***.*	99.6	
Hesperocorixa	1	***.*	99.6	
Belastoma	1	***.*	99.7	
Tubificidae	1	***.*	99.7	
Veliidae	1	***.*	99.8	
Polycentropodidae	1	***.*	99.8	
Tipulidae	1	***.*	99.8	
Thaumaleidae	1	***.*	99.9	
Tropisternus	1	***.*	99.9	
Corydalus	1	***.*	100.0	

Relative taxon contribution table continued.

Taxon	Average Abundance	Average Percent	Cumulative Percent
Hydrophilidae	1	***.*	100.0

A total of 46 taxa were collected in 12 samples.

Taxa identification, ecology, pollution information, and references for aquatic invertebrates collected in the previously listed samples. Abbreviations are listed on another page. References (Cite) can be found in the Literature Cited section.

Taxa	ID Cite	FFG	FFG Cite	MHBI	MHBI Cite	USFS TQ	Voltinism Class	Pollution Tolerance
Helichus	11	SH	10	5	45	72	S	
Deronecetes	10	PP	10	5	43	72	S	T
Microcylloepus	11	CG	10	2	45	104	S	
Hydrophilidae	10	PR	10	5	43	72	S	
Tropisternus	10	CG,PH	10,10	5	43	72	S	
Ceratopogonidae	13,14,15	PR,CG	14,13	6	45	108	U	
Chironomidae	13,16,25	CG,CF PR PP	40,40	6	43	108	U	
Chironominae	13,16,25	CG,CG	40,40	6	43	108	U	T
Orthocladiinae	13,16,25	CG,SC	40,40	6	43	108	U	T
Tanypodinae	13,16,25	PR,PP	40,40	7	43	72	U	T
Simuliidae	13,15,24	CF	39	6	45	108	U	
Simulium	13,15,24	CF	39	5	45	108	M	
Euparyphus	13,15	CG,SC	14,13	11	43	108	U	
Tabanus	13,15	PP	14	5	45	108	U	
Tipulidae	13,15	SH,DT,CG	37,37	4	45	72	U	
Baetis	18	CG,SC	18,18	6	45	72	M	T
Tricorythidae	18,19	CG	18	4	45	108	U	T
Tricorythodes	18,19	CG	18	4	45	108	U	T
Belostomatidae	23,24	PP	23	11	43	72	U	
Abedus	23,24	PP	23	11	43	72	U	
Belastoma	23,24	PP	23	11	43	72	U	
Hesperocorixa	20	PH	20	5	45	108	U	
Gerridae	20	PP	20	5	43	72	U	
Ambrysus	20	PP	20	11	43	90	U	
Veliidae	20	PP	20	11	43	72	U	
Petrophila	21	SC	21	5	45	72	U	
Hetaerina	23,24	PE	23	6	45	72	S	
Tubificidae	1	CG		10	45	108	U	T
Hydropsychidae	25	CF,PE	35,35	4	45	108	U	T
Cheumatopsyche	29	CF	35	5	45	108	U	T
Hydropsyche	29	CF	35	4	43	108	U	T
Hydroptilidae	25	PH,SC,CG	35	4	45	108	M	T
Hydroptila	29	PH,SC	35,35	6	45	108	M	T
Ochrotrichia	29	CG,PH	35,35	4	45	108	M	T
Oecetis	29	SH,PE	35,35	5	45	54	U	
Chimarra	29	CF	35	4	45	24	U	I
Polycentropodidae	25	CF,PE	35,35	6	45	72	U	
Hydracarina	5	PR,PA,OM	1,1	6	43	98	M	
Rhyacophila	29	PE,SC,CG,SH	35,35	1	43	30	U	I
Physella	31,	CG,OM	1,1	6	43	108	Z	
Planariidae	34,1	PR		6	45	108	Z	
Curculionidae	10	SH	10	5	45	100	S	

Taxa information table, continued.

Taxa	ID Cite	FFG	FFG Cite	MHBI	MHBI Cite	USFS TQ	Voltinism Class	Pollution Tolerance
Thaumaleidae	13,15	SC	14	5	45	108	U	
Caloparyphus	13,15	UN	14	5	45	108	U	
Corydalus	22	PE	22	0	45	90	S	I
Heterelmis	11	CG	10	4	43	104	S	

Abbreviations used in life history table.

MHBI - Modified Hilsenhoff Biotic Index (43,44)
USFS TQ - Pollution tolerance quotient (84)

Functional feeding groups (FFG)
CG - collector gatherers
CF - collector filterers
SC - scrapers
SH - shredders
PA - parasites
PR - predators
UN - unknown or highly variable
XY - xylophages (wood eaters)

Voltinism
M - multivoltine (short generation, < 1 year)
U - univoltine (1 generation per year)
S - semivoltine (> 1 year to complete lifecycle)
Z - unknown or highly variable

Pollution tollerance
I - pollution intollerant taxa
T - Pollution tollerant taxa

LITERATURE CITED

01 Pennak, R. W. 1989. Freshwater invertebrates of the United States, Third edition John Wiley and Sons, Inc, New York, 628P.

02 Klemm, D. J. 1972. Freshwater leeches (Annelida: Hirundinea of North America.

03 Hiltunen, J. K. and D. J. Klemm. 1980. A guide to the Nididae (Annelida: Clitellata: Oligochaeta) of North America U.S. Environmental Protection Agency, Cincinnati, Ohio 48 pages.

04 Foster, N. 1976. Freshwater Polycheates (Annelida) of North America U.S. Enviromental Protection Agency, Cincinnati, Ohio. 15 pages.

05 Smith, I. S. and D. R. Cook in Thorp, J. H. and A. P. Covich (editors). 1991. Water Mites, Chapter 16, pages 523-592 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc., San Diego, CA

06 Hobbs III, H. H. in Thorp J. H. and A. P. Covich (editors). 1991 Decapoda, Chapter 22, pages 823-858 in Ecology and Classification of Freshwater Inverebrates. Academic Press, Inc., San Diego, CA

07 Williams, W. D. 1976 Freshwater Isopods (Asellidae) of North America U. S. EPA, Cincinnati, Ohio. 45 pages.

08 Covich, A. P. and J. H. Thorp in Thorp, J. H. and A. P. Covich 1991 Crustacea: Introduction and Pericarida, Chapter 18, pages 665-689 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

09 Dodson, S. I. and D. G. Frey in Thorp, J. H. and A. P. Covich 1991 Cladocera and Other Branchiopoda, Chapter 20, pages 723-786 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

10 White, D. S., W. U. Brigham, and J.T. Doyen in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Aquatic Coleoptera, Chapter 19, pages 361-437 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

11 Brown, H. P. 1976. Aquatic Dryopoid beetles (Coleoptera) of the United States. U. S. EPA. Cincinnati, Ohio. 82 pages.

12 Waltz, R. D. and W. P. McCafferty. 1979 Freshwater Springtails (Hexapoda: Collembola) of North America. Purdue University Ag. Experiment Station Res. Bulletin 960. Laffayette, Indiana

13 Tesky, H. J. in Merritt, R. W. and Kenneth W. Cummins. 1984. Aquatic Diptera, Part One. Chapter 21, pages 448-466 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

14 Merritt, R. W. and E. I. Schlinger in Merritt, R. W. and Kenneth W. Cummins (editors). 1984 Aquatic Diptera, Part Two. Chapter 21, pages 467-490 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

15 Johannsen, O. A. 1977. Aquatic Diptera: Eggs, Larvae, and Pupae of Aquatic Flies. Published by the University, Ithaca, N.Y. 210 pages.

16 Wiederholm, T. (editor) 1983. Chironomidae of the Holarctic Region. Entomologica Scandinavica. 457 pages.

17 Darsic, R. F. Jr. and R. A. Ward. 1981. Identification and Geographical Distribution of the Mosquitoes of North America North of Mexico. American Mosquito Control Assoc., Fresno, CA. 313 pages.

18 Edmunds, G. F., Jr. in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Ephemeroptera, Chapter 10 pages 94-125 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

19 Edmunds, G. F., Jr., S. L. Jensen and L. Berner. 1976. The Mayflies of North and Central America. North Central Publishing Co., St. Paul, MN. 330 pages.

20 Polhemus, J. T. in Merritt, R. W. and K. W. Cummins. 1984. Aquatic and Semiaquatic Hemiptera, Chapter 14, pages 231-260 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

21 Lange, W.H. in Merritt, R. W. and Kenneth W. Cummins. 1984. Aquatic and Semiaquatic Lepidoptera, Chapter 18, pages 348-360 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

22 Evans, E. D. and H. H. Neunzig in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Megaloptera and

Aquatic Neuroptera, Chapter 15, pages 261-270, in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

23 Westfall, M. J., Jr. in Merritt R. W. and Kenneth W. Cummins (editors). 1984. Odonata, Chapter 11, pages 126-176 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

24 Needham, J. G. and M. J. Westfall, Jr. 1954. A Manual of Dragonflies of North America (Anisoptera). University of California Press, Berkely. 615 pages.

25 McCafferty, W. P. 1981. Aquatic Entomology. Jones and Bartlett Publishers, Inc., Boston. 448 pages.

26 Stewart, K. W. and B. P. Stark. 1988. Nymphs of North American Stonefly Genera (Plecoptera). Entomological Society of America. 460 pages.

27 Harper, P. P. and K. W. Stewart in Merritt R. W. and Kenneth W. Cummins. 1984. Plecoptera, Chapter 13, pages 182-230 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

28 Surdick, R. F. 1985. Nearctic Genera of Chloroperlinae (Plecoptera: Chloroperlinae).

29 Wiggins, G. B. 1978. Larvae of North American Caddisfly Genera (Tricoptera). University of Toronto Press. Toronto. 401 pages.

30 Slobodkin, L. B. and P. E. Bossert in Thorp, J. P. and A. P. Covich (editors) 1991. The Freshwater Cindaria or Coelenterates, Chapter 5, pages 125-143 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA.

31 Klemm, D. J. 1982. Freshwater Snails (Mollusca: Gastropoda) of North America.

32 Burch, J. B. 1973. Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. U. S. EPA. 176 pages

33 McMahon, R. F. in Thorp, J. H. and A. P. Covich (editors). 1991. Mollusca: Bivalvia, Chapter 11, pages 315-399 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

34 Kolasa, J. in Thorp, J. H. and A. P. Covich (editors). 1991. Flatworms: Turbellaria and Nemertea, Chapter 6, pages 144-171 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA.

35 Wiggins, G. B. in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Tricoptera, Chapter 16, pages 271-311 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

36 Morse, J. C. and R. W. Holzenthal in Merritt, R. W. and Kenneth W. Cummins Tricoptera Genera, Chapter 17, pages 312-347 in An introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

37 Byers, G. W. in Merritt, R. W. and K. W. Cummins Tipulidae, Chapter 22, pages 491-514 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

38 Newson, H. D. in Merritt, R. W. and K. W. Cummins Culicidae, Chapter 23, pages 515-533 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

39 Peterson, B. V. in Merritt, R. W. and Cummins, K. W. 1984 Simuliidae, Chapter 24, pages 534-550 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

40 Coffman, W. P. and L. C. Ferrington, Jr. in Merritt, R. W. and K. W. Cummins (editors). 1984. Chironomidae, Chapter 25, pages 551-652 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque,Iowa.

41 Hagen, K. S. in Merritt, R. W. and K. W. Cummins. (editors) 1984. Aquatic Hymenoptera, Chapter 20, pages 438-447 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

42 Cantrall, I. J. in Merritt, R. W. and K. W. Cummins. (editors) 1984. Orthoptera, Chapter 12, pages 177-182 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

43 Hilsenoff, W. L. 1988. Rapid Field Assessment of Organic Pollution w/ a Family Level Biotic Index. Journal of the North American Benthological Society 7:65-68

44 Hilsenoff, W. L. 1987. An Improved Index of Organic Stream Pollution. The Great Lakes Entomologist 20: 31-39

45 Bode, R. W., M. A. Novak, L. E. Abele. 1991. Methods for Rapid Biological Assessment of Streams. New York Department of Environmental Conservation. Albany, N.Y.

46 Simpson, E. H. 1949. Measurement of Diversity. Nature 163:688

47 Shannon, C. E. and W. Weaver. 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana, IL

48 Alatalo, R. V. 1981. Problems in the Measurement of Evenness in Ecology. Okios 37:199-204

49 Resh, V. H. and D. M. Rosenberg (editors). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York. 488 pages

50 Resh, V. H. and J. K. Jackson in Resh V. H. and D. M. Roseberg (editors). 1993. Rapid Assessment Approaches to Biomonitoring Using Benthic Macroinvertebrates, pages 195-133 in Freshwater Biomonitoring and Benthic Macroinvertebrates.Chapman and Hall, New York.

51 Weber, C. I. (editor). 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-640/4-73-001. Environmental Protection Agency. Cincinnati, Ohio.

52 Resh, V. H. and Grodhaus in G. W. Frankie and C. S. Koehler (editors). 1983. Aquatic Insects in Urban Environments, pages 247-276 in Urban Entomology: Interdisciplinary Perspectives. Praeger Publishers, New York.

53 Lenat, D. R. 1988. Water Quality Assessment of Streams Using a Qualitative Collection Method for Benthic Macroinvertebrates. Journal of the North American Benthological Society 7:222-33.

54 Neveu, A. 1973. Estimation of the Production of Larval Populations of the Genus Simulium (Diptera, Nematocera). Annuals Hydrobiologic 4:183-199.

55 Ladle, M., Bass, J. A. B. and Jenkins, W. R. 1972. Studies on Production and Food Consumption by the Larval Simuliidae (Diptera) of a Chalk Stream. Hydrobiologia 39:429-488

56 Speir, J. A. and Anderson, N. H. 1974. Use of Emergence Data for Estimating Annual Production of Aquatic Insects. Limnology and Oceanography 19:154-156.

57 McClure, R. G. and Stewart, K. W. 1976. Life Cycle and Production of the Mayfly Choroterpes (Neochoroterpes) Mexicanus Allen (Ephemeroptera: Leptophlebiidae). Annuals of the Entomological Society of America 69:134-144

58 Hudson, P. L. and Swanson, G. A. 1972. Production and Standing Crop of Hexagenia (Ephemeroptera) in a Large Reservoir. Studies in Natural Science, Natural Science Research Institute, Eastern New Mexico University. Volume 1, No. 4, 42 pp.

59 Horst, T. J. and Marzolf, G. R. 1975. Production Ecology of Burrowing Mayflies in a Kansas Resevoir. Verh. Internat. Verin. Limnol. 19:3029-3038

60 Pearson, W. D. and Kramer, R. H. 1972. Drift and Production of Two Aquatic Insects in a Mountain Stream. Ecological Monographs 24:365-385

61 Waters, T. F. 1966. Production Rate, Population Density and Drift of a Stream Invertebrate. Ecology 47:595-604

62 Zelinka, M. 1973. Die Eintagsfliegen (Ephemeroptera) in Forellenbachen der Beskiden. II. Produktion. Hydrobiologia 42:13-19

63 Tsuda, M. in Kazak, Z. and A. Hillbricht-Ilkowska (editors). 1972 Interim Results of the Yoshino River Productivity Survey, Especially on Benthic Animals. In Productivity Problems of Freshwaters. IBP, UNESCO, Polish Science Publ., Warsaw,

64 Waters, T. F. and Crawford, G. W. 1973. Annual Production of a Stream Mayfly Population: a Comparison of Methods. Limnology and Oceanography 18:286-296

65 Castro, L. B. 1975. Okologie und Produktionsbiologie von Agapetus fuscipes Curt. im Breitembach 1971-1972. Arch. Hydrobiol./Suppl. 45:305-375

66 Cushman, R. M., Elwood, J. W. and Hildebrand, S. G. 1975. Production Dynamics of Alloperla mediana Banks (Plecoptera: Chloroperlidae) and Diplectrona modesta Banks (Tricoptera: Hydropsychidae) in Walker Branch, Tennessee.Oakridge National Laboratory, Environmental Science Division Publication No. 785, 66 pages.

67 Decamps,H. and Lafont, M. 1974. Cycles Vivaux et Production des Micrasema Pyreneennes dans Mousses D'eau Cuorante (Tricoptera: Brachycentridae). Annls. Limnol. 10:1-32

68 Giani, N., and Laville, H. 1973. Biological Cycle and Production of Sialis lutaria L. (Megaloptera) in Port-Bielh Lake (Central Pyrennees). Annls. Limnol. 9:45-61

69 Yamamoto, G. in Kazak, Z. and Hillbricht-Ilkowska, A. (editors). 1972. Tropic Structure in Lake Tatsu-Numa, an Acidotropic Lake in Japan, with Special Reference to the Importance of the Terrestrial Community. In "Productivity Problems of Freshwaters"IBP, UNESCO, Polish Science Publication, Warsaw.

70 Andersson, E. 1969. Life cycle and Growth of Asellus aquaticus (L.) Rep. Inst. Freshwater Res. Drottningholm

49:5-26

71 Mann, K. H. in Edmondson, W. T. and Winberg, G. G. (editors). 1971. Use of the Allen Curve Method for Calculating Benthic Production. Pages 160-165 in A Manual on Methods for the Assessment of Secondary Productivity in Freshwaters.IBP Handbook No. 17, Blackwell Science Publication, Oxford and Edinburgh

72 Potter, D. W. B. and Learner, M. A. 1974. A Study of Benthic Macroinvertebrates of a Shallow Eutrophic Reservoir in South Wales with Emphasis on the Chironomidae (Diptera); their Life Histories and Production. Arch. Hydrobiol. 74:186-226

73 Beattie, M. et al. in Kazak, Z. and Hillbricht-Ilkowska, A. (editors) 1972. Limnological Studies on Tjeukemeer- a Typical Dutch "Polder Reservoir" pages 421-446 in Productivity Problems of Freshwaters. IBP, UNESCO, Polish Science Publication, Warsaw.

74 Tilley, L. J. 1968. The Structure and Dynamics of Cone Spring. Ecological Monographs 38:169-197

75 Mathias, J. A. 1971. Energy Flow and Secondary Production of the Amphipods Hyalella azteca and Crangonyx richmondensis occidentalis in Marion Lake, British Colombia. Journal of the Fisheries Research Board of Canada 28:711-726

76 Cooper, W. E. 1965. Dynamics and Production of a Natural Population of a Freshwater Amphipod, Hyalella azteca. Ecological Monographs 35:377-394

77 Eckblad, J. W. 1973. Population Studies of Three Aquatic Gastropods in an Intermittent Backwater. Hydrobiologia 41:199-219

78 Gillespie, D. M. 1969. Populations of Four Species of Molluscs in the Madison River, Yellowstone National Park. Limnology and Oceanography 14:101-114

79 Jonasson,P. M. 1972. Ecology and Production of the Profundal Benthos in Relation to Phytoplankton in Lake Esrom. Oikos (Suppl.) 14:1-148

80 Hunter, R. D. 1975. Growth, Fecundity and Bioenergetics in Three Populations of Lymnaea palustris in Upstate New York. Ecology 56:50-63

81 Learner, M. A. and Potter, D. W. B. 1974. Life History and Production of the Leech Helobdella stagnalis (L.) (Hirudinea) in a Shallow Eutrophic Reservoir in South Wales. Journal of Animal Ecology 43:199-208.

82 Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid Bioassessment Protocols for use in streams and rivers: Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency, EPA/444/4-89-001.

83 Washington, H. G. 1984. Diversity, Biotic and Similarity indicies, A review with special relevance to aquatic ecosystems. Water Research 6:653-694

84 Winget, R. N. and F. A. Mangum. 1979. Biotic condition index: integrated biological, physical and chemical stream parameters for management. USDA Forest Service, Intermountain Region, Ogden, UT, Contract No. 40-84M8-8524, 51 pages.

85 Weber, C. I. (editor). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. U.S. Environmental Protection Agency, EPA-670/4-73-001.

86 Lloyd, M., J. H. Zar, and J. R. Karr. 1968 On the calculation of information - theoretical measures of diversity. American Midland Naturalist 79:257-272.

87 Ludwig, J. A. and J. F. Reynolds. 1988. Statistical ecology - a primer on methods and computing John Wiley and Sons, New York. 329 pages.

88 Elliot, J. M. 1971 Some methods for the Statistical analysis of samples of benthic invertebrates Freshwater Biological Association, Scientific Publication No. 25

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-1, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae	Orthocladiinae		L	172
Diptera	Simuliidae		Simulium	L	215
Diptera	Stratiomyidae		Caloparyphus	L	11
Ephemeroptera	Baetidae		Baetis	L	204
Hemiptera	Naucoridae		Ambrysus	L	11
Trichoptera	Hydropsychidae		Hydropsyche	L	65
Trichoptera	Hydroptilidae			L	22

Total: 7 taxa					699

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-2, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	11
Class: Insecta					
Diptera	Chironomidae	Orthocladiinae		L	11
Diptera	Simuliidae		Simulium	L	11
Diptera	Stratiomyidae		Caloparyphus	L	43
Diptera	Tabanidae		Tabanus	L	22
Ephemeroptera	Baetidae		Baetis	L	32
Hemiptera	Naucoridae		Ambrysus	A	43
Trichoptera	Hydropsychidae		Hydropsyche	L	108

Total: 8 taxa					280

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-3, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Simuliidae		Simulium	L	11419
Ephemeroptera	Baetidae		Baetis	L	645
Hemiptera	Naucoridae		Ambrysus	A	22
Lepidoptera	Pyralidae		Petrophila	L	22
Trichoptera	Hydropsychidae		Hydropsyche	L	151

Total: 5 taxa					12258

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-4, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae	Chironominae		L	11
Diptera	Chironomidae	Orthocladiinae		L	129
Diptera	Chironomidae	Tanypodinae		L	54
Diptera	Simuliidae		Simulium	L	54
Diptera	Stratiomyidae		Euparyphus	L	11
Diptera	Stratiomyidae		Caloparyphus	L	43
Diptera	Tipulidae			L	11
Ephemeroptera	Baetidae		Baetis	L	194
Ephemeroptera	Tricorythidae		Tricorythodes	L	22
Hemiptera	Gerridae			A	11
Hemiptera	Naucoridae		Ambrysus	A	86
Trichoptera	Hydropsychidae		Hydropsyche	L	118
Trichoptera	Leptoceridae		Oecetis	L	11
Trichoptera	Rhyacophilidae		Rhyacophila	L	11

Total: 14 taxa					763

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-5, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	32
Class: Insecta					
Coleoptera	Curculionidae			A	22
Coleoptera	Dytiscidae		Deronecetes	A	22
Coleoptera	Elmidae		Microcylloepus	L	11
Diptera	Chironomidae			P	54
Diptera	Chironomidae	Chironominae		L	43
Diptera	Chironomidae	Orthocladiinae		L	140
Diptera	Chironomidae	Tanypodinae		L	75
Diptera	Simuliidae			P	32
Diptera	Simuliidae		Simulium	L	785
Diptera	Stratiomyidae		Euparyphus	L	129
Diptera	Stratiomyidae		Caloparyphus	L	376
Ephemeroptera	Baetidae		Baetis	L	624
Ephemeroptera	Tricorythidae		Tricorythodes	L	65
Hemiptera	Naucoridae		Ambrysus	L	86
Odonata	Calopterygidae		Hetaerina	L	462
Trichoptera	Hydropsychidae		Hydropsyche	L	43
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae		Physella	A	11
Phylum: Platyhelminthes					
Class: Turbellaria					
Tricladida	Planariidae			A	11

Total: 19 taxa					3022

Taxonomic list and abundances of aquatic invertebrates collected 06/19/95 at station TIERRA-6, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae	Orthocladiinae		L	22
Diptera	Chironomidae	Tanypodinae		L	11
Diptera	Simuliidae		Simulium	L	118
Diptera	Stratiomyidae		Euparyphus	L	11
Diptera	Stratiomyidae		Caloparyphus	L	43
Diptera	Tabanidae		Tabanus	L	11
Ephemeroptera	Baetidae		Baetis	L	215
Hemiptera	Naucoridae		Ambrysus	A	226
Trichoptera	Hydropsychidae		Hydropsyche	L	75
Trichoptera	Hydroptilidae		Hydroptila	L	11
Trichoptera	Leptoceridae		Oecetis	L	11

Total: 11 taxa					753

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-1, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dytiscidae		Deronecetes	A	11
Coleoptera	Hydrophilidae			L	11
Coleoptera	Hydrophilidae		Tropisternus	A	11
Diptera	Simuliidae		Simulium	L	22
Ephemeroptera	Tricorythidae		Tricorythodes	L	22
Hemiptera	Belostomatidae			A	22
Hemiptera	Corixidae		Hesperocorixa	A	11
Hemiptera	Gerridae			A	11
Hemiptera	Veliidae			A	11
Trichoptera	Hydropsychidae		Hydropsyche	L	32
Trichoptera	Hydroptilidae		Hydroptila	L	32
Trichoptera	Rhyacophilidae		Rhyacophila	L	11
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae		Physella	A	54

Total: 13 taxa					258

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-2, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Annelida					
Class: Oligochaeta					
Tubificida	Tubificidae			A	11
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	32
Class: Insecta					
Diptera	Chironomidae			P	11
Diptera	Chironomidae	Orthocladiinae		L	11
Diptera	Thaumaleidae			L	11
Ephemeroptera	Tricorythidae		Tricorythodes	L	11
Hemiptera	Belostomatidae		Belastoma	A	11
Trichoptera	Hydropsychidae		Cheumatopsyche	L	11
Trichoptera	Hydropsychidae		Hydropsyche	L	32
Trichoptera	Hydroptilidae			L	32

Total: 10 taxa					172

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-3, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	65
Class: Insecta					
Coleoptera	Dryopidae		Helichus	A	22
Coleoptera	Dytiscidae		Deronecetes	A	22
Coleoptera	Elmidae		Microcylloepus	L	280
Coleoptera	Elmidae		Microcylloepus	A	22
Coleoptera	Elmidae		Heterelmis	L	22
Diptera	Ceratopogonidae			L	22
Diptera	Chironomidae	Orthocladiinae		L	280
Diptera	Stratiomyidae		Caloparyphus	L	22
Diptera	Tabanidae		Tabanus	L	32
Ephemeroptera	Baetidae		Baetis	L	43
Ephemeroptera	Tricorythidae		Tricorythodes	L	22
Hemiptera	Belostomatidae		Abedus	A	11
Hemiptera	Naucoridae		Ambrysus	A	43
Megaloptera	Corydalidae		Corydalus	A	11
Trichoptera	Hydropsychidae			P	22
Trichoptera	Hydropsychidae		Hydropsyche	L	7312
Trichoptera	Hydroptilidae			P	43
Trichoptera	Hydroptilidae		Hydroptila	L	22
Trichoptera	Hydroptilidae		Ochrotrichia	L	108
Trichoptera	Philopotamidae		Chimarra	L	108
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae		Physella	A	22

Total: 21 taxa					8548

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-4, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae	Orthocladiinae		L	11
Diptera	Simuliidae		Simulium	L	54
Trichoptera	Hydropsychidae		Hydropsyche	L	32
Trichoptera	Polycentropodidae			L	11

Total: 4 taxa					108

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-5, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	11
Class: Insecta					
Coleoptera	Dryopidae		Helichus	L	43
Diptera	Simuliidae		Simulium	L	11
Ephemeroptera	Tricorythidae		Tricorythodes	L	65
Trichoptera	Hydropsychidae		Cheumatopsyche	L	22
Trichoptera	Hydropsychidae		Hydropsyche	L	43

Total: 6 taxa					194

Taxonomic list and abundances of aquatic invertebrates collected 07/12/95 at station PERCHA-6, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dryopidae		Helichus	L	11
Ephemeroptera	Tricorythidae			L	22
Ephemeroptera	Tricorythidae		Tricorythodes	L	11
Trichoptera	Hydropsychidae		Cheumatopsyche	L	43

Total: 4 taxa					86

Aquatic Benthic Macroinvertebrate Report

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INTRODUCTION

The goal of the Clean Water Act is to preserve and restore the biological integrity of aquatic resources. Monitoring is a tool we use to measure our management successes and failures and base our resource allocation adjustments on to meet this goal. Under the Clean Water Act federal agencies have the responsibility for monitoring water quality on federally managed lands.

Aquatic macroinvertebrates are an important component of aquatic ecosystems and have long been used to evaluate water quality. Among all the components of an aquatic ecosystem they are one of the best suited for monitoring and basing resource decisions on because they are numerous in almost all streams and lakes; they respond to changing environmental conditions, either natural or anthropogenic; they are readily collected and identified; they are not very mobile; they have sufficiently long life cycles to enable effects to be integrated over an annual period; and they provide a vital link in the food chain between primary producers (algae and macrophytes) and fish. They have also been shown to be a cost effective monitoring tool for evaluating the effects of management changes on stream and riparian condition.

This report provides a general assessment of the aquatic ecosystem based on the aquatic macroinvertebrate community. It was assumed the sampling area was representative of a larger area. The information provided should be integrated with other data collected in the watershed to gain a more complete understanding of pollution sources, impacts, and trends.

SAMPLING LOCATIONS

The information in this report is based on data collected at the sites listed below. Additional site location and management information for each site is shown in Table 1.

Station	Location
PERCHA-1	Percha Creek, Sierra County, New Mexico
PERCHA-2	Percha Creek, Sierra County, New Mexico
PERCHA-3	Percha Creek, Sierra County, New Mexico
PERCHA-4	Percha Creek, Sierra County, New Mexico
PERCHA-5	Percha Creek, Sierra County, New Mexico
PERCHA-6	Percha Creek, Sierra County, New Mexico
TIERRA-1	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-2	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-3	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-4	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-5	Tierra Blanca Creek, Sierra County, New Mexico
TIERRA-6	Tierra Blanca Creek, Sierra County, New Mexico

Table 1. Sampling locations. Distance is in miles, elevation is in feet. NP = data not provided.

Station	Latitude	Longitude	Stream order	Elev.	Distance to mouth	HUC	Ecoregion / Sub-ecoregion	Major landuse	Comments
PERCHA-1	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-2	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-3	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-4	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-5	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
PERCHA-6	33	107	1	4000	20.00	130301	Southern Basin and Range	Grazing	
TIERRA-1	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-2	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-3	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-4	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-5	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	
TIERRA-6	33	107	1	4000	25.00	130301	Southern Basin and Range	Grazing	

SAMPLING METHODS

Table 2. Sampling dates, methodology and comments.

Station	Date	Sample #	Sampling Method	Habitat Sampled	Sampling Area (m^2)	Comments
PERCHA-1	09/22/95	1 of 1	SURBER	UNKNOWN	0.093	small boulders
PERCHA-1	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand
PERCHA-2	09/22/95	1 of 1	SURBER	UNKNOWN	0.093	gravel
PERCHA-2	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand/small boulders
PERCHA-3	09/22/95	1 of 1	SURBER	UNKNOWN	0.093	gravel
PERCHA-3	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	coarse gravel
PERCHA-4	09/22/95	1 of 1	SURBER	UNKNOWN	0.093	fine sediment
PERCHA-4	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	sand
PERCHA-5	09/22/95	1 of 1	SURBER	UNKNOWN	0.093	gravel
PERCHA-5	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	small rocks
PERCHA-6	09/22/95	1 of 1	SURBER	UNKNOWN	1.000	None
PERCHA-6	07/12/95	1 of 1	SURBER	UNKNOWN	0.093	gravel
TIERRA-1	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	boulders
TIERRA-1	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel w/iron carbon
TIERRA-2	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	gravel/sediment
TIERRA-2	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel w/iron carbon
TIERRA-3	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	gravel/sediment
TIERRA-3	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	boulder habitat
TIERRA-4	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	sediment
TIERRA-4	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	bedrock
TIERRA-5	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	sediment
TIERRA-5	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	sand w/vegetation
TIERRA-6	10/07/95	1 of 1	SURBER	UNKNOWN	0.093	fine gravel
TIERRA-6	06/19/95	1 of 1	SURBER	UNKNOWN	0.093	gravel

LABORATORY PROCESSING

Samples were identified at the BLM Aquatic Ecosystem Laboratory in Logan, Utah. Samples were processed following Elliott (88). Individual samples were first placed in a white enamel pan and observed under a magnifying glass. Large and less-numerous organisms were removed. The sample was then subsampled by dispersing it evenly within a No. 60 sieve (250 micron) located in a water-filled enamel pan. The sieve was then lifted out of the water and split into two equal parts with a spatula. This procedure was repeated until approximately 250 organisms remained in the sub-sample. Organisims were removed from the sub-sample using a stereoscope with 8-40X magnification. If less than 250 organisms were found in the subsample additional subsamples were taken. The amount of the original sample which was identified is shown in Table 3. The organisms were then identified and counted by well-qualified taxonomists. An effort was made to identify organisms to a consistent taxonomic level. Insects were primarily identified to genus, with the exception of Chironomidae which were identified to subfamily. Non-insect invertebrates were identified to various taxonomic levels depending on the availability of identification keys. Voucher specimens were retained for all unique taxa.

Table 3. Percentage of each sample that was identified and any laboratory comments.

Station	Date	Sample #	Field split %	Lab split %	% id'd	Comments
PERCHA-1	09/22/95	1 of 1	None	None	100	None
PERCHA-1	07/12/95	1 of 1	None	None	100	None
PERCHA-2	09/22/95	1 of 1	None	None	100	None
PERCHA-2	07/12/95	1 of 1	None	None	100	None
PERCHA-3	09/22/95	1 of 1	None	None	100	None
PERCHA-3	07/12/95	1 of 1	None	50	50	None
PERCHA-4	09/22/95	1 of 1	None	None	100	None
PERCHA-4	07/12/95	1 of 1	None	None	100	None
PERCHA-5	09/22/95	1 of 1	None	None	100	None
PERCHA-5	07/12/95	1 of 1	None	None	100	None
PERCHA-6	09/22/95	1 of 1	None	None	100	None
PERCHA-6	07/12/95	1 of 1	None	None	100	None
TIERRA-1	10/07/95	1 of 1	None	None	100	None
TIERRA-1	06/19/95	1 of 1	None	None	100	None
TIERRA-2	10/07/95	1 of 1	None	None	100	None
TIERRA-2	06/19/95	1 of 1	None	None	100	None
TIERRA-3	10/07/95	1 of 1	None	None	100	None
TIERRA-3	06/19/95	1 of 1	None	50	50	None
TIERRA-4	10/07/95	1 of 1	None	None	100	None
TIERRA-4	06/19/95	1 of 1	None	None	100	None
TIERRA-5	10/07/95	1 of 1	None	None	100	None
TIERRA-5	06/19/95	1 of 1	None	None	100	None
TIERRA-6	10/07/95	1 of 1	None	None	100	None
TIERRA-6	06/19/95	1 of 1	None	None	100	None

DATA ANALYSIS

Interpretation of the health and integrity of the aquatic ecosystem was based on a number of aquatic macroinvertebrate indices and life history characteristics of individual taxa and physical habitat and water chemistry data (if collected). The indices used were those recommended for use by the U.S. Environmental Protection Agency (82) and others (43, 44, 45, 50,53, 79). These indices should be compared to those calculated for other sites, either impacted or non-impacted, and be used to document changes over time at the same site. Abundance data is shown as the number per square meter (#/m^2) for quantitative samples and the number per sample for qualitative samples.

Community summary statistics

Richness and enumeration measures
Taxa richness - Richness is a component and estimate of community structure and stream health based on the number of distinct taxa. Taxa richness normally decreases with decreasing water quality (50). In some situations organic enrichment resulta in an increase in the number of taxa, including EPT taxa (82).

Abundance - The abundance of aquatic macroinvertebrates is an indicator of habitat availability, suitability and fish food abundance. It may be reduced or increased depending on the type of pollution.

EPT - A summary of the taxa richness within the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are considered to be sensitive to pollution. EPT generally increases with increasing water quality (53).

Family level measures - All families are separated and counted. The number and diversity of families normally decreases with decreasing water quality (50).

Diversity measures
Ecological diversity is a measure of community structure defined by the relationship between the number of distinct taxa (S) and their relative abundances (n). Washington (83) reviewed the use of diversity indices in aquatic ecosystems and suggested the use of Simpson's D, however, Shannon's index is widely used and dbar has been used by the EPA (85) and the USFS (84).

Margalef's index - Based on the presumed linear relationship between the number of species and the logarithm of the number of individuals. It is seldom used today (83) and is included for comparison to historical data where this index was used. It is calculated as S-1/ln(n).

Menhinick's index - This index is correlated to sample size and is not widely used in aquatic ecology (83) and is included primarily for comparison to historical data where this index was used. It is calculated as S/SQRT(n).

Shannon's H - Shannon's H' (47) is widely used in community ecology. It is a measure of the average degree of uncertainty in predicting what species an individual chosen at random from a collection of species and individuals will belong. This average uncertainty increases as the number of species increases and as the distribution of individuals among taxa becomes even. The higher the number the greater the diversity. However, small cold streams have naturally low diversity and for this reason some have criticized the use of H'.

Dbar - Dbar has been used by the EPA (85) and the USFS (84). Values range from 0 to 3.32 log N. It was calculated based on the machine formula presented by Lloyd et al. (86).

Simpson - Simpson's (46) diversity index is defined as the probability of picking two individuals that are of the same group. Abundant taxa receive more weight. Values range from 0-1; the higher the number the greater the diversity.

Evenness - Evenness is a measure of the distribution of taxa within a community. The evenness index used in this report is that recommended by Ludwig and Reynolds (87). Values range from 0-1 and approach zero as a single taxon becomes more dominant.

<u>Biotic indices</u>
Biotic indices make use of the indicator taxa concept. Taxa are assigned water quality tolerance values (TV) or quotients (TQ) based on their tolerance to pollution. The most common biotic indices in use in the United States are the modified Hilsenhoff Biotic Index and the USFS Biotic Condition Index.

Modified Hilsenhoff Biotic Index - This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It is best at detecting organic pollution. All taxa are assigned a TV from 0 - for taxa known to occur only in high quality water, to 10 - for taxa known to occur in severely polluted waters. TV values came from Hilsenhoff (43, 44) and Bode et al. (45). The MHBI is calculated by multiplying the TV for each taxon by the taxon abundance, summing the products, and dividing by the number total sample abundance. Waters with values 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted.

USFS Community tolerant quotient/biotic condition index -
Unimpacted benthic aquatic macroinvertebrate community structure (CTQp) is predicted based on total alkalinity, sulfate, substrate size, and stream gradient. The actual benthic aquatic macroinvertebrate community structure (CTQd) corrected for taxa dominance is then divided by the CTQp and multiplied by 1030 to determine the biotic condition index (BCI). All taxa are assigned a TQ from 0- pollution intolerant, to 108 - pollution tolerant (84). Waters having a BCIs >90 are considered excellent, 80-90 good, 72-79 fair, and <72 poor. This index has been widely used by the USFS and BLM in the western United States.

Functional feeding group classification

Shredders - Shredders utilize coarse particulate organic matter (CPOM). They are sensitive to changes in riparian vegetation and can be good indicators of the presence of toxicants. Xylophages are shredders which eat wood and are typically long lived.

Scrapers - Scrapers feed on periphyton (attached algae and associated material). Scraper populations increase with increasing abundance of diatoms and decrease as filamentous algae, mosses, and vascular plants increase. Scrapers decrease in relative abundance in response to sedimentation and organic pollution.

Collector-filterers - Collector-filterers feed on suspended fine particulate organic matter (FPOM). Collector-filterers are sensitive to toxicants attached to suspended particles.

Collector-gatherers - Collector-gatherers feed on deposited fine particulate organic matter. Collector-gatherers are sensitive to deposited toxicants.

Predators - Predators feed on living animal tissue.

The primary difference between the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols (RBP) II and III is RBP II invertebrates are identified in the field to family and for RBP III invertebrates are identified in the laboratory to genus or species (82). The degree of impairment at a site is based on the relative differences observed for eight primary metrics calculated between a sampling site and a control or reference site. In many cases reference data are unavailable, nevertheless these metrics can be used to evaluate general water quality and they can be used when reference data becomes available (Table 6).

The eight metrics used in RBP II and III are:

1. Species richness

2. Modified Hilsenhoff Biotic Index

3. Ratio of scraper to collector-filterer + scraper functional feeding groups - This ratio reflects the riffle/run community food base and can provide insight into the nature of potential disturbance factors. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an abundance of a particular food source. The predominant feeding strategy reflects the type of impact detected. Scrapers increase with increased abundance of diatoms and decrease as filamentous algae and aquatic mosses increase. Filamentous algae and aquatic mosses provide good attachment sites for collector-filterers and the organic enrichment often responsible for high abundance of filamentous algae provides FPOM utilized by filterers. Filterer-collectors are also sensitive to toxicants bound to fine particles and may decrease in abundance when exposed to such sources. The scraper:collector-filterer + scrapers ratio may not be a good indicator of organic enrichment if adsorbing toxicants are present.

4. Ratio of EPT to Chironomidae + EPT abundances - This ratio evaluates the relative abundance of these indicator groups as a measure of community balance. Good biotic condition is reflected in communities having a fairly even distribution among all four major taxonomic groups and with substantial representation in the sensitive groups Ephemeroptera, Plecoptera, and Trichoptera. Skewed populations having a disproportionately high number of the generally tolerant Chironomidae relative to the more sensitive groups may indicate environmental stress (82). In general, Chironomids tend to become increasingly dominant along a gradient of increasing enrichment or heavy metal concentration.

5. Percent contribution of dominant taxon - A community dominated by few taxa indicates environmental stress (82). Values range from 0-1. Lower values indicate a more balanced community balance and better water quality.

6. EPT richness - The total number of taxa within the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are considered to be sensitive to pollution. EPT generally increases with increasing water quality (53).

7. Ratio of shredder functional feeding group and total number of individuals collected - This metric evaluates potential impairment as indicated by the relative presence of shredders. Shredders are sensitive to riparian impacts and are good indicators of the availability of CPOM and toxic effects. The degree of toxicant effects on shredders versus filterers depends on the the toxicant, the size of the particle it is attached to, and its organic particle adsorption efficiency. Toxicants of a terrestrial source (e.g., pesticides, herbicides) accumulate on CPOM prior to leaf fall and may have a substantial effect on shredders.

Water quality impairment indicator groups

The presence, absence or relative dominance of a particular taxon or group of taxa can provide information on the relative water quality at a site. Taxa were labeled as pollution intolerant if they are known to occur primarily in unpolluted waters. Pollution tolerant taxa are those known to be tolerant of fine sediment, high water temperatures, or high organic loads. Tolerance values are shown in the life history table.

Pollution Intolerant taxa
Intolerant mayflies - Mayflies are common in most waters and several taxa are ultra sensitive to fine sediment, low dissolved oxygen, or high water temperatures. The major pollution intolerant famlies are Ephemerellidae, Heptageniidae, and some Baetidae.

Intolerant stoneflies - Most stoneflies are sensitive to changes in substrate composition, water temperature, and retention of coarse organic matter (CPOM, leaves, twigs). Pteronarcys is a common stonefly which lives longer than 1 year and is sensitive to changes in substrate and CPOM retention. Nemouridae are common shredder stoneflies that are intolerant of organic loading and fine sediment.

Intolerant caddisflies - Intolerant caddisflies include the families Arctopsychidae, Glossosomatidae, Philopotamidae, Psychomyiidae, and many Rhyacophilidae and Limnephilidae. These families are widely distributed in most unpolluted waters and prefer coarse substrates.

Corydalidae - Helgramites are long lived and sensitive to excessive fine sediment deposition. Their presence indicates stable good habitat conditions.

Intolerant dipterans - Non-chironomidae dipterans which are intolerant of habitat degradation. Taxa include Blephariceridae, Deuterophebiidae, Dixidae, Pelecorhynchidae.

Intolerant Chironomidae - Includes members of the subfamilies Prodiamesinae, Podonominae, and Diamesinae.

Intolerant molluscs - Hydrobiidae snails and Unionidae mussels have moderate pollution tolerances.

Pollution Tolerant taxon
Tolerant mayflies - In contrast to many mayflies these taxa are tolerant of warmer water, and higher fine sediment orgainc loads. Taxa include Tricorythodes, Hexagenia, Caenis, Acentrella, and Baetis tricaudatis.

Tolerant caddisflies - Hydropsyche, Cheumatopsyche, hydroptilids, Helicopsyche, Hesperophylax, Limnephilus, and some Leptocerids are tolerant of warmer water and higher fine sediment levels.

Tolerant beetles - Agabetus, Carabidae, Helichus, Haliplidae, and many psephenids and elmids are tolerant of warmer water, and higher levels of fine sediment and nutrient enrichment.

Tolerant odonates - Most odonates are tolerant of warm water, high nutrients, fine sediment, and dense communities of filamentous algae.

Tolerant dipterans - Antocha, Athericidae, Ceraptopogonidae, Culicidae, Dolichopodidae, Empididae, Ephydridae, Muscidae, Psychodidae, Stratimoyidae, and Tabanidae are families which are typically abundant in waters with low habitat integrity.

Tolerant Chironomidae - The sub-families Chironominae, Orthocladiinae, and

Tanypodinae are tolerant of fine sediment and organic enrichment.

Simuliidae - Abundant in all lotic waters, but excessively high numbers (>40% total abundance) may indicate nutrient enrichment.

Tolerant amphipods - Common in springs and downstream of dams, numerous amphipods in other stream types may indicate nutrient enrichment.

Tolerant snails - Most pulmonate snails are tolerant of warm water and fine sediment.

Oligochaeta - Highly tolerant of fine sediment.

Leeches - Tolerant of fine sediment and organic enrichment.

<u>Voltinism</u>

Voltinism refers to life cycle length. Taxa requiring more than one year to complete their life cycle are more dependent on stable conditions than short lived taxa. A community with very few taxa with life cycles longer than eight months might indicate instability or a recent pollution event. Taxa were classified as being multivoltine, (multiple generations per year), univoltine, (a single generation per year), or semivoltine, (life cycles last more than one year). Classification was based on published and unpublished sources.

Community summary statistics. EPT = Insect orders, Ephemeroptera, Plecoptera, Trichoptera. MHBI = Modified Hilsenhoff Biotic Index. Abundance data is number per meter squared for quantitative samples and number per sample for qualitative samples. NC = Not calculated. * = unable to calculate.

Richness and enumeration measures

Station	Date	Total richness	Total abundance	EPT richness	EPT abundance	# of families	Dominant family	Dom. Family abundance	Dom. Family % contribution
PERCHA-1	07/12/95	13	258	4	97	12	Physidae	54	20.80
PERCHA-1	09/22/95	3	75	2	65	2	Hydropsychidae	65	85.70
PERCHA-2	07/12/95	10	172	4	86	8	Hydropsychidae	43	25.00
PERCHA-2	09/22/95	0	0	0	0	0	none	******	***.**
PERCHA-3	07/12/95	21	8398	8	7677	17	Hydropsychidae	7333	87.30
PERCHA-3	09/22/95	1	11	1	11	1	more than one	11	100.00
PERCHA-4	07/12/95	4	108	2	43	4	Simuliidae	54	50.00
PERCHA-4	09/22/95	1	11	0	0	1	Gomphidae	11	100.00
PERCHA-5	07/12/95	6	194	3	129	5	Tricorythidae	65	33.30
PERCHA-5	09/22/95	0	0	0	0	0	none	******	***.**
PERCHA-6	07/12/95	4	86	3	75	3	Hydropsychidae	43	50.00
PERCHA-6	09/22/95	1	1	1	1	1	Hydropsychidae	1	100.00
TIERRA-1	06/19/95	7	699	3	290	7	Simuliidae	215	30.80
TIERRA-1	10/07/95	10	5011	2	484	7	Simuliidae	4376	87.30
TIERRA-2	06/19/95	8	280	2	140	8	Hydropsychidae	108	38.50
TIERRA-2	10/07/95	4	280	0	0	4	Stratiomyidae	194	69.20
TIERRA-3	06/19/95	5	12258	2	796	5	Simuliidae	11419	93.20
TIERRA-3	10/07/95	22	3194	4	355	16	Stratiomyidae	1290	40.40
TIERRA-4	06/19/95	14	763	5	355	11	Baetidae	194	25.40
TIERRA-4	10/07/95	16	559	2	32	13	Stratiomyidae	280	50.00
TIERRA-5	06/19/95	19	3022	3	731	14	Simuliidae	817	27.00
TIERRA-5	10/07/95	17	656	2	108	11	Chironomidae	194	29.50
TIERRA-6	06/19/95	11	753	4	312	9	Naucoridae	226	30.00
TIERRA-6	10/07/95	1	22	0	0	1	Stratiomyidae	22	100.00
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Mean		8	1534	2	491	7		1228	57.88

Community summary statistics, continued.

Diversity indices

Station	Date	Shannon diversity	Dbar diversity	Simpson diversity	Margalef diversity	Menhinick diversity	evenness
PERCHA-1	07/12/95	2.395	3.455	0.104	2.161	0.809	0.863
PERCHA-1	09/22/95	0.796	1.149	0.545	0.463	0.346	0.686
PERCHA-2	07/12/95	2.155	3.108	0.128	1.748	0.762	0.895
PERCHA-2	09/22/95	0.000	**.***	**.***	0.000	**.***	**.***
PERCHA-3	07/12/95	0.712	1.027	0.760	2.213	0.229	0.304
PERCHA-3	09/22/95	0.000	**.***	1.000	0.000	0.305	**.***
PERCHA-4	07/12/95	1.168	1.685	0.354	0.641	0.386	0.823
PERCHA-4	09/22/95	0.000	**.***	1.000	0.000	0.305	**.***
PERCHA-5	07/12/95	1.600	2.308	0.224	0.950	0.431	0.875
PERCHA-5	09/22/95	0.000	**.***	**.***	0.000	**.***	**.***
PERCHA-6	07/12/95	1.213	1.750	0.336	0.673	0.431	0.836
PERCHA-6	09/22/95	0.000	0.000	**.***	**.***	1.000	**.***
TIERRA-1	06/19/95	1.523	2.197	0.250	0.916	0.265	0.839
TIERRA-1	10/07/95	0.679	0.979	0.700	1.056	0.141	0.441
TIERRA-2	06/19/95	1.766	2.548	0.216	1.243	0.478	0.748
TIERRA-2	10/07/95	0.917	1.323	0.516	0.533	0.239	0.624
TIERRA-3	06/19/95	0.297	0.429	0.871	0.425	0.045	0.429
TIERRA-3	10/07/95	2.204	3.179	0.194	2.603	0.389	0.514
TIERRA-4	06/19/95	2.180	3.145	0.143	1.958	0.507	0.761
TIERRA-4	10/07/95	2.004	2.891	0.238	2.371	0.677	0.500
TIERRA-5	06/19/95	2.195	3.167	0.156	2.246	0.346	0.679
TIERRA-5	10/07/95	2.529	3.649	0.097	2.467	0.664	0.804
TIERRA-6	06/19/95	1.809	2.609	0.210	1.510	0.401	0.735
TIERRA-6	10/07/95	0.000	**.***	1.000	0.000	0.216	**.***
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Mean		1.563	2.137	0.431	1.454	0.426	0.686

Community summary statistics, continued.

Biotic indices

Station	Date	MHBI	Indication	CTQp	CTQa	CTQd	BCI	Indication
				United States Forest Service Biotic Condition Index				
PERCHA-1	07/12/95	4.33	Moderate organic enrichment	53	85	88	60	Poor
PERCHA-1	09/22/95	4.43	Moderate organic enrichment	NC	108	108	NC	Unable to calculate
PERCHA-2	07/12/95	4.87	Moderate organic enrichment	53	103	104	51	Poor
PERCHA-2	09/22/95	**.**		NC	***	***	NC	Unable to calculate
PERCHA-3	07/12/95	4.05	Moderate organic enrichment	53	95	95	56	Poor
PERCHA-3	09/22/95	0.00	Little organic enricment	NC	72	72	NC	Unable to calculate
PERCHA-4	07/12/95	4.90	Moderate organic enrichment	53	99	101	52	Poor
PERCHA-4	09/22/95	4.00	Slight organic enrichment	NC	108	108	NC	Unable to calculate
PERCHA-5	07/12/95	4.50	Moderate organic enrichment	53	100	100	53	Poor
PERCHA-5	09/22/95	**.**		NC	***	***	NC	Unable to calculate
PERCHA-6	07/12/95	4.62	Moderate organic enrichment	53	99	101	53	Poor
PERCHA-6	09/22/95	4.00	Slight organic enrichment	NC	108	***	NC	Unable to calculate
TIERRA-1	06/19/95	5.34	Moderate organic enrichment	53	100	100	53	Poor
TIERRA-1	10/07/95	4.84	Moderate organic enrichment	NC	99	102	NC	Unable to calculate
TIERRA-2	06/19/95	4.04	Moderate organic enrichment	53	100	100	53	Poor
TIERRA-2	10/07/95	4.50	Moderate organic enrichment	NC	90	94	NC	Unable to calculate
TIERRA-3	06/19/95	5.03	Moderate organic enrichment	53	90	93	57	Poor
TIERRA-3	10/07/95	5.03	Moderate organic enrichment	NC	94	96	NC	Unable to calculate
TIERRA-4	06/19/95	4.69	Moderate organic enrichment	53	87	89	59	Poor
TIERRA-4	10/07/95	4.58	Moderate organic enrichment	NC	93	93	NC	Unable to calculate
TIERRA-5	06/19/95	5.11	Moderate organic enrichment	53	98	97	55	Poor
TIERRA-5	10/07/95	4.00	Slight organic enrichment	NC	94	95	NC	Unable to calculate
TIERRA-6	06/19/95	3.69	Slight organic enrichment	53	95	95	56	Poor
TIERRA-6	10/07/95	5.00	Moderate organic enrichment	NC	108	108	NC	Unable to calculate
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Mean		4.55		53	97	97	55	

Community summary statistics, continued.

Taxa pollution tolerance summary.

		Intolerant taxa				Tolerant taxa			
Station	Date	# of taxa	%	sample abundance	%	# of taxa	%	sample abundance	%
PERCHA-1	07/12/95	1	7.7	11	4.3	4	30.8	97	37.6
PERCHA-1	09/22/95	0	0.0	0	0.0	2	66.7	65	86.7
PERCHA-2	07/12/95	0	0.0	0	0.0	6	60.0	108	62.8
PERCHA-2	09/22/95	0	***.*	0	***.*	0	***.*	0	***.*
PERCHA-3	07/12/95	2	9.5	118	1.4	9	42.9	7871	93.7
PERCHA-3	09/22/95	0	0.0	0	0.0	0	0.0	0	0.0
PERCHA-4	07/12/95	0	0.0	0	0.0	2	50.0	43	39.8
PERCHA-4	09/22/95	0	0.0	0	0.0	0	0.0	0	0.0
PERCHA-5	07/12/95	0	0.0	0	0.0	3	50.0	129	66.5
PERCHA-5	09/22/95	0	***.*	0	***.*	0	***.*	0	***.*
PERCHA-6	07/12/95	0	0.0	0	0.0	3	75.0	75	87.2
PERCHA-6	09/22/95	0	0.0	0	0.0	1	100.0	1	100.0
TIERRA-1	06/19/95	0	0.0	0	0.0	4	57.1	462	66.1
TIERRA-1	10/07/95	0	0.0	0	0.0	3	30.0	495	9.9
TIERRA-2	06/19/95	0	0.0	0	0.0	3	37.5	151	53.9
TIERRA-2	10/07/95	0	0.0	0	0.0	1	25.0	11	3.9
TIERRA-3	06/19/95	0	0.0	0	0.0	2	40.0	796	6.5
TIERRA-3	10/07/95	1	4.5	11	0.3	6	27.3	946	29.6
TIERRA-4	06/19/95	1	7.1	11	1.4	6	42.9	527	69.1
TIERRA-4	10/07/95	0	0.0	0	0.0	5	31.3	65	11.6
TIERRA-5	06/19/95	0	0.0	0	0.0	7	36.8	1011	33.5
TIERRA-5	10/07/95	0	0.0	0	0.0	5	29.4	280	42.7
TIERRA-6	06/19/95	0	0.0	0	0.0	5	45.5	333	44.2
TIERRA-6	10/07/95	0	0.0	0	0.0	0	0.0	0	0.0
Mean		0	2.5	6	0.4	3	38.9	561	36.6

Taxa richness by functional feeding group; number of taxa per meter squared for quantitative samples and number of taxa per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Shredders	Scrapers	Collector filterers	Collector gatherers	Predators	Unknown
PERCHA-1	07/12/95	2 (15)	0 (0)	2 (15)	3 (23)	6 (46)	0 (0)
PERCHA-1	09/22/95	0 (0)	0 (0)	2 (67)	1 (33)	0 (0)	0 (0)
PERCHA-2	07/12/95	1 (10)	1 (10)	2 (20)	4 (40)	2 (20)	0 (0)
PERCHA-2	09/22/95	0 (*******	0 (*******	0 (*******	0 (*******	0 (******	0 (**********)
PERCHA-3	07/12/95	3 (14)	0 (0)	3 (14)	7 (33)	7 (33)	1 (5)
PERCHA-3	09/22/95	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
PERCHA-4	07/12/95	0 (0)	0 (0)	3 (75)	1 (25)	0 (0)	0 (0)
PERCHA-4	09/22/95	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
PERCHA-5	07/12/95	1 (17)	0 (0)	3 (50)	1 (17)	1 (17)	0 (0)
PERCHA-5	09/22/95	0 (*******	0 (*******	0 (*******	0 (*******	0 (******	0 (**********)
PERCHA-6	07/12/95	1 (25)	0 (0)	1 (25)	2 (50)	0 (0)	0 (0)
PERCHA-6	09/22/95	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
TIERRA-1	06/19/95	1 (14)	0 (0)	2 (29)	2 (29)	1 (14)	1 (14)
TIERRA-1	10/07/95	1 (10)	0 (0)	4 (40)	3 (30)	1 (10)	1 (10)
TIERRA-2	06/19/95	0 (0)	0 (0)	2 (25)	2 (25)	3 (38)	1 (13)
TIERRA-2	10/07/95	0 (0)	0 (0)	1 (25)	0 (0)	2 (50)	1 (25)
TIERRA-3	06/19/95	0 (0)	1 (20)	2 (40)	1 (20)	1 (20)	0 (0)
TIERRA-3	10/07/95	1 (5)	2 (9)	6 (27)	5 (23)	6 (27)	2 (9)
TIERRA-4	06/19/95	2 (14)	0 (0)	2 (14)	5 (36)	4 (29)	1 (7)
TIERRA-4	10/07/95	2 (13)	1 (6)	0 (0)	5 (31)	7 (44)	1 (6)
TIERRA-5	06/19/95	1 (5)	0 (0)	3 (16)	8 (42)	6 (32)	1 (5)
TIERRA-5	10/07/95	3 (18)	0 (0)	2 (12)	6 (35)	5 (29)	1 (6)
TIERRA-6	06/19/95	2 (18)	0 (0)	2 (18)	3 (27)	3 (27)	1 (9)
TIERRA-6	10/07/95	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
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Mean		1 (11)	0 (3)	2 (22)	2 (30)	2 (28)	1 (7)

Invertebrate abundance by functional feeding group; abundance per meter squared for quantitative samples and abundance per sample for qualitative samples. Numbers in parentheses are percentages.

Station	Date	Shredders	Scrapers	Collector filterers	Collector gatherers	Predators	Unknown
PERCHA-1	07/12/95	43 (17)	0 (0)	54 (21)	86 (33)	75 (29)	0 (0)
PERCHA-1	09/22/95	0 (0)	0 (0)	65 (87)	11 (15)	0 (0)	0 (0)
PERCHA-2	07/12/95	32 (19)	11 (6)	43 (25)	43 (25)	43 (25)	0 (0)
PERCHA-2	09/22/95	0 (*******	0 (*******	0 (*******	0 (*******	0 (******	0 (**********)
PERCHA-3	07/12/95	86 (1)	0 (0)	7441 (89)	645 (8)	204 (2)	22 (0)
PERCHA-3	09/22/95	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	11 (100)
PERCHA-4	07/12/95	0 (0)	0 (0)	97 (90)	11 (10)	0 (0)	0 (0)
PERCHA-4	09/22/95	0 (0)	0 (0)	0 (0)	0 (0)	11 (100)	0 (0)
PERCHA-5	07/12/95	43 (22)	0 (0)	75 (39)	65 (34)	11 (6)	0 (0)
PERCHA-5	09/22/95	0 (*******	0 (*******	0 (*******	0 (*******	0 (******	0 (**********)
PERCHA-6	07/12/95	11 (13)	0 (0)	43 (50)	32 (37)	0 (0)	0 (0)
PERCHA-6	09/22/95	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
TIERRA-1	06/19/95	22 (3)	0 (0)	280 (40)	376 (54)	11 (2)	11 (2)
TIERRA-1	10/07/95	11 (0)	0 (0)	4925 (98)	43 (1)	11 (0)	22 (0)
TIERRA-2	06/19/95	0 (0)	0 (0)	118 (42)	43 (15)	75 (27)	43 (15)
TIERRA-2	10/07/95	0 (0)	0 (0)	43 (15)	0 (0)	43 (15)	194 (69)
TIERRA-3	06/19/95	0 (0)	22 (0)	11570 (94)	645 (5)	22 (0)	0 (0)
TIERRA-3	10/07/95	183 (6)	43 (1)	548 (17)	677 (21)	462 (14)	1280 (40)
TIERRA-4	06/19/95	22 (3)	0 (0)	172 (23)	366 (48)	161 (21)	43 (6)
TIERRA-4	10/07/95	22 (4)	97 (17)	0 (0)	86 (15)	108 (19)	247 (44)
TIERRA-5	06/19/95	22 (1)	0 (0)	860 (28)	1075 (36)	688 (23)	376 (12)
TIERRA-5	10/07/95	65 (10)	0 (0)	204 (31)	247 (38)	118 (18)	22 (3)
TIERRA-6	06/19/95	22 (3)	0 (0)	194 (26)	247 (33)	247 (33)	43 (6)
TIERRA-6	10/07/95	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	22 (100)
Mean		24 (2)	7 (0)	1114 (73)	196 (13)	95 (6)	97 (6)

U.S. Environmetal Protection Agency Rapid Bioassessment Protocol III metric values. MHBI = Modified Hilsenhoff Biotic Index, SC = scraper, CF = collecter-filterer, EPT = Insect orders, Ephemeroptera, Plecoptera, Trichoptera. Abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples. NC = Not calculated. * = unable to calculate.

Station	Date	Total richness	MHBI	SC:CF ratio	EPT: Chironomidae ratio	% contribution dominant taxon	EPT richness	Riffle sample SH:abundance (% shredders) ratio
PERCHA-1	07/12/95	13	4.33	0.000	1.000	20.800	4	16.7
PERCHA-1	09/22/95	3	4.43	0.000	0.857	85.700	2	0.0
PERCHA-2	07/12/95	10	4.87	0.200	0.800	25.000	4	18.6
PERCHA-2	09/22/95	0	**.**	**.***	**.***	**.***	0	***.*
PERCHA-3	07/12/95	21	4.05	0.000	0.965	87.300	8	1.0
PERCHA-3	09/22/95	1	0.00	**.***	1.000	**.***	1	0.0
PERCHA-4	07/12/95	4	4.90	0.000	0.800	50.000	2	0.0
PERCHA-4	09/22/95	1	4.00	**.***	**.***	**.***	0	0.0
PERCHA-5	07/12/95	6	4.50	0.000	1.000	33.300	3	22.2
PERCHA-5	09/22/95	0	**.**	**.***	**.***	**.***	0	***.*
PERCHA-6	07/12/95	4	4.62	0.000	1.000	50.000	3	12.8
PERCHA-6	09/22/95	1	4.00	0.000	1.000	**.***	1	0.0
TIERRA-1	06/19/95	7	5.34	0.000	0.628	30.800	3	3.1
TIERRA-1	10/07/95	10	4.84	0.000	0.978	87.300	2	0.2
TIERRA-2	06/19/95	8	4.04	0.000	0.929	38.500	2	0.0
TIERRA-2	10/07/95	4	4.50	0.000	0.000	69.200	0	0.0
TIERRA-3	06/19/95	5	5.03	0.002	1.000	93.200	2	0.0
TIERRA-3	10/07/95	22	5.03	0.073	0.337	40.400	4	5.7
TIERRA-4	06/19/95	14	4.69	0.000	0.647	25.400	5	2.9
TIERRA-4	10/07/95	16	4.58	1.000	0.500	50.000	2	3.9
TIERRA-5	06/19/95	19	5.11	0.000	0.701	27.000	3	0.7
TIERRA-5	10/07/95	17	4.00	0.000	0.357	29.500	2	9.9
TIERRA-6	06/19/95	11	3.69	0.000	0.906	30.000	4	2.9
TIERRA-6	10/07/95	1	5.00	**.***	**.***	**.***	0	0.0
Mean		8	**.**	0.067	0.770	**.***	2	1.6

Taxonomic list for all samples collected in the New Mexico State University.

Order	Family	Subfamily	Genus/species	Relative occurrence
Phylum: Annelida				
Class: Oligochaeta				
Tubificida	Tubificidae			very rare
Phylum: Arthropoda				
Class: Arachnoidea				
Hydracarina				common
Class: Crustacea				
Ostracoda				rare
Class: Insecta				
Coleoptera	Curculionidae			very rare
Coleoptera	Dryopidae		Helichus	rare
Coleoptera	Dytiscidae		Deronecetes	rare
Coleoptera	Elmidae		Heterelmis	very rare
Coleoptera	Elmidae		Microcylloepus	rare
Coleoptera	Elmidae		Stenelmis	very rare
Coleoptera	Haliplidae		Peltodytes	very rare
Coleoptera	Hydrophilidae			very rare
Coleoptera	Hydrophilidae		Tropisternus	very rare
Diptera	Ceratopogonidae			very rare
Diptera	Chironomidae			rare
Diptera	Chironomidae	Chironominae		rare
Diptera	Chironomidae	Orthocladiinae		abundant
Diptera	Chironomidae	Tanypodinae		common
Diptera	Empididae		Clinocera	very rare
Diptera	Simuliidae			rare
Diptera	Simuliidae		Simulium	abundant
Diptera	Stratiomyidae		Caloparyphus	abundant
Diptera	Stratiomyidae		Euparyphus	common
Diptera	Tabanidae		Tabanus	rare
Diptera	Thaumaleidae			very rare
Diptera	Tipulidae			very rare
Ephemeroptera	Baetidae		Baetis	common
Ephemeroptera	Tricorythidae			very rare
Ephemeroptera	Tricorythidae		Tricorythodes	common
Hemiptera	Belostomatidae			very rare
Hemiptera	Belostomatidae		Abedus	very rare
Hemiptera	Belostomatidae		Belastoma	very rare
Hemiptera	Corixidae		Hesperocorixa	very rare
Hemiptera	Gerridae			very rare
Hemiptera	Naucoridae		Ambrysus	common
Hemiptera	Veliidae			very rare
Hemiptera	Veliidae		Rhagovelia	very rare
Lepidoptera				very rare
Lepidoptera	Pyralidae		Petrophila	rare
Megaloptera	Corydalidae		Corydalus	very rare
Odonata	Aeshnidae			very rare
Odonata	Calopterygidae			very rare
Odonata	Calopterygidae		Hetaerina	rare
Odonata	Coenagrionidae			very rare
Odonata	Coenagrionidae		Argia	very rare
Odonata	Gomphidae			rare
Trichoptera				very rare
Trichoptera	Hydropsychidae			very rare
Trichoptera	Hydropsychidae		Cheumatopsyche	rare
Trichoptera	Hydropsychidae		Hydropsyche	abundant
Trichoptera	Hydroptilidae			rare
Trichoptera	Hydroptilidae		Hydroptila	rare
Trichoptera	Hydroptilidae		Ochrotrichia	very rare
Trichoptera	Leptoceridae		Oecetis	very rare
Trichoptera	Philopotamidae		Chimarra	very rare
Trichoptera	Philopotamidae		Dolophilodes	very rare
Trichoptera	Polycentropodidae			very rare
Trichoptera	Rhyacophilidae		Rhyacophila	very rare
Phylum: Mollusca				
Class: Gastropoda				
Basommatophora	Physidae		Physella	rare
Phylum: Platyhelminthes				
Class: Turbellaria				
Tricladida	Planariidae			very rare

A total of 59 taxa were collected in 24 samples. Relative occurrence was determined by the presence or absence of taxa within individual samples. Very abundant = >75%, abundant = 50-74%, common = 30-49%, rare = 10-24%, very rare <10% of the samples

contained that particular taxon.

Relative contribution of taxon collected from all samples collected in the New Mexico State University. Abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples. ***.* = <0.1%.

Taxon	Average abundance	Average percent	Cumulative percent	
Simulium	715	46.4	46.4	
Hydropsyche	367	23.8	70.2	
Caloparyphus	96	6.2	76.4	
Baetis	86	5.6	82.0	
Orthocladiinae	50	3.3	85.3	
				Five dominant taxa
Hetaerina	27	1.8	87.1	
Ambrysus	27	1.8	88.8	
Microcylloepus	13	0.8	89.7	
Tanypodinae	13	0.8	90.5	
Chironominae	12	0.8	91.3	
				Ten dominant taxa
Tricorythodes	12	0.8	92.0	
Simuliidae	11	0.7	92.8	
Helichus	11	0.7	93.5	
Ostracoda	10	0.6	94.1	
Euparyphus	9	0.6	94.7	
Chironomidae	8	0.5	95.3	
Hydracarina	7	0.5	95.7	
Petrophila	5	0.3	96.1	
Cheumatopsyche	5	0.3	96.4	
Chimarra	4	0.3	96.7	
Ochrotrichia	4	0.3	97.0	
Hydroptilidae	4	0.3	97.3	
Physella	4	0.3	97.5	
Argia	4	0.2	97.8	
Tabanus	4	0.2	98.0	
Hydroptila	3	0.2	98.2	
Stenelmis	3	0.2	98.3	
Deronecetes	2	0.1	98.5	
Lepidoptera	2	0.1	98.6	
Curculionidae	1	0.1	98.7	
Rhagovelia	1	0.1	98.8	
Aeshnidae	1	0.1	98.9	
Gomphidae	1	0.1	99.0	
Tricorythidae	1	0.1	99.0	
Ceratopogonidae	1	0.1	99.1	
Heterelmis	1	0.1	99.2	
Belostomatidae	1	0.1	99.2	
Hydropsychidae	1	0.1	99.3	
Gerridae	1	0.1	99.3	
Oecetis	1	0.1	99.4	
Coenagrionidae	1	0.1	99.4	
Rhyacophila	1	0.1	99.5	
Abedus	1	***.*	99.5	
Trichoptera	1	***.*	99.6	
Calopterygidae	1	***.*	99.6	

Relative taxon contribution table continued.

Taxon	Average Abundance	Average Percent	Cumulative Percent
Tubificidae	1	***.*	99.6
Tipulidae	1	***.*	99.7
Dolophilodes	1	***.*	99.7
Belastoma	1	***.*	99.7
Hesperocorixa	1	***.*	99.7
Polycentropodidae	1	***.*	99.8
Tropisternus	1	***.*	99.8
Planariidae	1	***.*	99.8
Veliidae	1	***.*	99.9
Thaumaleidae	1	***.*	99.9
Hydrophilidae	1	***.*	99.9
Corydalus	1	***.*	99.9
Clinocera	1	***.*	100.0
Peltodytes	1	***.*	100.0

A total of 59 taxa were collected in 24 samples.

Taxa identification, ecology, pollution information, and references for aquatic invertebrates collected in the previously listed samples. Abbreviations are listed on another page. References (Cite) can be found in the Literature Cited section.

Taxa	ID Cite	FFG	FFG Cite	MHBI	MHBI Cite	USFS TQ	Voltinism Class	Pollution Tolerance
Helichus	11	SH	10	5	45	72	S	
Deronecetes	10	PP	10	5	43	72	S	T
Microcylloepus	11	CG	10	2	45	104	S	
Stenelmis	11	SC,CG	10,10	5	45	104	S	
Peltodytes	10	PH,SH PR	10,10	5	45	54	S	
Hydrophilidae	10	PR	10	5	43	72	S	
Tropisternus	10	CG,PH	10,10	5	43	72	S	
Ceratopogonidae	13,14,15	PR,CG	14,13	6	45	108	U	
Chironomidae	13,16,25	CG,CF PR PP	40,40	6	43	108	U	
Chironominae	13,16,25	CG,CG	40,40	6	43	108	U	T
Orthocladiinae	13,16,25	CG,SC	40,40	6	43	108	U	T
Tanypodinae	13,16,25	PR,PP	40,40	7	43	72	U	T
Clinocera	13,15	UN	14	6	45	95	U	
Simuliidae	13,15,24	CF	39	6	45	108	U	
Simulium	13,15,24	CF	39	5	45	108	M	
Euparyphus	13,15	CG,SC	14,13	11	43	108	U	
Tabanus	13,15	PP	14	5	45	108	U	
Tipulidae	13,15	SH,DT,CG	37,37	4	45	72	U	
Baetis	18	CG,SC	18,18	6	45	72	M	T
Tricorythidae	18,19	CG	18	4	45	108	U	T
Tricorythodes	18,19	CG	18	4	45	108	U	T
Belostomatidae	23,24	PP	23	11	43	72	U	
Abedus	23,24	PP	23	11	43	72	U	
Belastoma	23,24	PP	23	11	43	72	U	
Hesperocorixa	20	PH	20	5	45	108	U	
Gerridae	20	PP	20	5	43	72	U	
Ambrysus	20	PP	20	11	43	90	U	
Veliidae	20	PP	20	11	43	72	U	
Rhagovelia	20	PP	20	11	43	72	U	
Lepidoptera	21	SH	21	11	43	72	U	
Petrophila	21	SC	21	5	45	72	U	
Aeshnidae	23,24	PE	23	3	45	72	S	
Calopterygidae	23,24	PR	23	5	45	72	S	
Hetaerina	23,24	PE	23	6	45	72	S	
Coenagrionidae	23,24	PE	23	9	45	108	U	
Argia	23,24	PE	23	6	45	108	U	
Gomphidae	23,24	PE	23	4	45	108	S	
Tubificidae	1	CG		10	45	108	U	T
Trichoptera	35	UN	35	11	43	72	Z	
Hydropsychidae	25	CF,PE	35,35	4	45	108	U	T
Cheumatopsyche	29	CF	35	5	45	108	U	T
Hydropsyche	29	CF	35	4	43	108	U	T

Taxa information table, continued.

Taxa	ID Cite	FFG	FFG Cite	MHBI	MHBI Cite	USFS TQ	Voltinism Class	Pollution Tolerance
Hydroptilidae	25	PH,SC,CG	35	4	45	108	M	T
Hydroptila	29	PH,SC	35,35	6	45	108	M	T
Ochrotrichia	29	CG,PH	35,35	4	45	108	M	T
Oecetis	29	SH,PE	35,35	5	45	54	U	
Chimarra	29	CF	35	4	45	24	U	I
Dolophilodes	29	CF	35	3	45	24	U	I
Polycentropodidae	25	CF,PE	35,35	6	45	72	U	
Hydracarina	5	PR,PA,OM	1,1	6	43	98	M	
Rhyacophila	29	PE,SC,CG,SH	35,35	1	43	30	U	I
Physella	31	CG,OM	1,1	6	43	108	Z	
Planariidae	34,1	PR		6	45	108	Z	
Curculionidae	10	SH	10	5	45	100	S	
Thaumaleidae	13,15	SC	14	5	45	108	U	
Caloparyphus	13,15	UN	14	5	45	108	U	
Corydalus	22	PE	22	0	45	90	S	I
Heterelmis	11	CG	10	4	43	104	S	
Ostracoda	1	CF,SC	1,1	11	43	108	M	

Abbreviations used in life history table.

MHBI - Modified Hilsenhoff Biotic Index (43,44)
USFS TQ - Pollution tolerance quotient (84)

<u>Functional feeding groups (FFG)</u>
CG - collector gatherers
CF - collector filterers
SC - scrapers
SH - shredders
PA - parasites
PR - predators
UN - unknown or highly variable
XY - xylophages (wood eaters)

<u>Voltinism</u>
M - multivoltine (short generation, < 1 year)
U - univoltine (1 generation per year)
S - semivoltine (> 1 year to complete lifecycle)
Z - unknown or highly variable

<u>Pollution tollerance</u>
I - pollution intollerant taxa
T - Pollution tollerant taxa

LITERATURE CITED

01 Pennak, R. W. 1989. Freshwater invertebrates of the United States, Third edition John Wiley and Sons, Inc, New York, 628P.

02 Klemm, D. J. 1972. Freshwater leeches (Annelida: Hirundinea of North America.

03 Hiltunen, J. K. and D. J. Klemm. 1980. A guide to the Nididae (Annelida: Clitellata: Oligochaeta) of North America U.S. Environmental Protection Agency, Cincinnati, Ohio 48 pages.

04 Foster, N. 1976. Freshwater Polycheates (Annelida) of North America U.S. Enviromental Protection Agency, Cincinnati, Ohio. 15 pages.

05 Smith, I. S. and D. R. Cook in Thorp, J. H. and A. P. Covich (editors). 1991. Water Mites, Chapter 16, pages 523-592 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc., San Diego, CA

06 Hobbs III, H. H. in Thorp J. H. and A. P. Covich (editors). 1991 Decapoda, Chapter 22, pages 823-858 in Ecology and Classification of Freshwater Inverebrates. Academic Press, Inc., San Diego, CA

07 Williams, W. D. 1976 Freshwater Isopods (Asellidae) of North America U. S. EPA, Cincinnati, Ohio. 45 pages.

08 Covich, A. P. and J. H. Thorp in Thorp, J. H. and A. P. Covich 1991 Crustacea: Introduction and Pericarida, Chapter 18, pages 665-689 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

09 Dodson, S. I. and D. G. Frey in Thorp, J. H. and A. P. Covich 1991 Cladocera and Other Branchiopoda, Chapter 20, pages 723-786 in Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

10 White, D. S., W. U. Brigham, and J.T. Doyen in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Aquatic Coleoptera, Chapter 19, pages 361-437 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

11 Brown, H. P. 1976. Aquatic Dryopoid beetles (Coleoptera) of the United States. U. S. EPA. Cincinnati, Ohio. 82 pages.

12 Waltz, R. D. and W. P. McCafferty. 1979 Freshwater Springtails (Hexapoda: Collembola) of North America. Purdue University Ag. Experiment Station Res. Bulletin 960. Laffayette, Indiana

13 Tesky, H. J. in Merritt, R. W. and Kenneth W. Cummins. 1984. Aquatic Diptera, Part One. Chapter 21, pages 448-466 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

14 Merritt, R. W. and E. I. Schlinger in Merritt, R. W. and Kenneth W. Cummins (editors). 1984 Aquatic Diptera, Part Two. Chapter 21, pages 467-490 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

15 Johannsen, O. A. 1977. Aquatic Diptera: Eggs, Larvae, and Pupae of Aquatic Flies. Published by the University, Ithaca, N.Y. 210 pages.

16 Wiederholm, T. (editor) 1983. Chironomidae of the Holarctic Region. Entomologica Scandinavica. 457 pages.

17 Darsic, R. F. Jr. and R. A. Ward. 1981. Identification and Geographical Distribution of the Mosquitoes of North America North of Mexico. American Mosquito Control Assoc., Fresno, CA. 313 pages.

18 Edmunds, G. F., Jr. in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Ephemeroptera, Chapter 10 pages 94-125 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

19 Edmunds, G. F., Jr., S. L. Jensen and L. Berner. 1976. The Mayflies of North and Central America. North Central Publishing Co., St. Paul, MN. 330 pages.

20 Polhemus,J. T. in Merritt, R. W. and K. W. Cummins. 1984. Aquatic and Semiaquatic Hemiptera, Chapter 14, pages 231-260 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

21 Lange, W.H. in Merritt, R. W. and Kenneth W. Cummins. 1984. Aquatic and Semiaquatic Lepidoptera, Chapter 18, pages 348-360 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

22 Evans, E. D. and H. H. Neunzig in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Megaloptera and

Aquatic Neuroptera, Chapter 15, pages 261-270, in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

23 Westfall, M. J., Jr. in Merritt R. W. and Kenneth W. Cummins (editors). 1984. Odonata, Chapter 11, pages 126-176 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

24 Needham, J. G. and M. J. Westfall, Jr. 1954. A Manual of Dragonflies of North America (Anisoptera). University of California Press, Berkely. 615 pages.

25 McCafferty, W. P. 1981. Aquatic Entomology. Jones and Bartlett Publishers, Inc., Boston. 448 pages.

26 Stewart, K. W. and B. P. Stark. 1988. Nymphs of North American Stonefly Genera (Plecoptera). Entomological Society of America. 460 pages.

27 Harper, P. P. and K. W. Stewart in Merritt R. W. and Kenneth W. Cummins. 1984. Plecoptera, Chapter 13, pages 182-230 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

28 Surdick, R. F. 1985. Nearctic Genera of Chloroperlinae (Plecoptera: Chloroperlinae).

29 Wiggins, G. B. 1978. Larvae of North American Caddisfly Genera (Tricoptera). University of Toronto Press. Toronto. 401 pages.

30 Slobodkin, L. B. and P. E. Bossert in Thorp, J. P. and A. P. Covich (editors) 1991. The Freshwater Cindaria or Coelenterates, Chapter 5, pages 125-143 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA.

31 Klemm, D. J. 1982. Freshwater Snails (Mollusca: Gastropoda) of North America.

32 Burch, J. B. 1973. Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. U. S. EPA. 176 pages

33 McMahon, R. F. in Thorp, J. H. and A. P. Covich (editors). 1991. Mollusca: Bivalvia, Chapter 11, pages 315-399 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA

34 Kolasa, J. in Thorp, J. H. and A. P. Covich (editors). 1991. Flatworms: Turbellaria and Nemertea, Chapter 6, pages 144-171 in Ecology and Classification of Freshwater Invertebrates. Academic Press, Inc. San Diego, CA.

35 Wiggins, G. B. in Merritt, R. W. and Kenneth W. Cummins (editors). 1984. Tricoptera, Chapter 16, pages 271-311 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

36 Morse, J. C. and R. W. Holzenthal in Merritt, R. W. and Kenneth W. Cummins Tricoptera Genera, Chapter 17, pages 312-347 in An introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

37 Byers, G. W. in Merritt, R. W. and K. W. Cummins Tipulidae, Chapter 22, pages 491-514 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

38 Newson, H. D. in Merritt, R. W. and K. W. Cummins Culicidae, Chapter 23, pages 515-533 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

39 Peterson, B. V. in Merritt, R. W. and Cummins, K. W. 1984 Simuliidae, Chapter 24, pages 534-550 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

40 Coffman, W. P. and L. C. Ferrington, Jr. in Merritt, R. W. and K. W. Cummins (editors). 1984. Chironomidae, Chapter 25, pages 551-652 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque,Iowa.

41 Hagen, K. S. in Merritt, R. W. and K. W. Cummins. (editors) 1984. Aquatic Hymenoptera, Chapter 20, pages 438-447 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

42 Cantrall, I. J. in Merritt, R. W. and K. W. Cummins. (editors) 1984. Orthoptera, Chapter 12, pages 177-182 in An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa.

43 Hilsenoff, W. L. 1988. Rapid Field Assessment of Organic Pollution w/ a Family Level Biotic Index. Journal of the North American Benthological Society 7:65-68

44 Hilsenoff, W. L. 1987. An Improved Index of Organic Stream Pollution. The Great Lakes Entomologist 20: 31-39

45 Bode, R. W., M. A. Novak, L. E. Abele. 1991. Methods for Rapid Biological Assessment of Streams. New York Department of Environmental Conservation. Albany, N.Y.

46 Simpson, E. H. 1949. Measurement of Diversity. Nature 163:688

47 Shannon, C. E. and W. Weaver. 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana, IL

48 Alatalo, R. V. 1981. Problems in the Measurement of Evenness in Ecology. Okios 37:199-204

49 Resh, V. H. and D. M. Rosenberg (editors). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York. 488 pages

50 Resh, V. H. and J. K. Jackson in Resh V. H. and D. M. Roseberg (editors). 1993. Rapid Assessment Approaches to Biomonitoring Using Benthic Macroinvertebrates, pages 195-133 in Freshwater Biomonitoring and Benthic Macroinvertebrates.Chapman and Hall, New York.

51 Weber, C. I. (editor). 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-640/4-73-001. Environmental Protection Agency. Cincinnati, Ohio.

52 Resh, V. H. and Grodhaus in G. W. Frankie and C. S. Koehler (editors). 1983. Aquatic Insects in Urban Environments, pages 247-276 in Urban Entomology: Interdisciplinary Perspectives. Praeger Publishers, New York.

53 Lenat, D. R. 1988. Water Quality Assessment of Streams Using a Qualitative Collection Method for Benthic Macroinvertebrates. Journal of the North American Benthological Society 7:222-33.

54 Neveu, A. 1973. Estimation of the Production of Larval Populations of the Genus Simulium (Diptera, Nematocera). Annuals Hydrobiologic 4:183-199.

55 Ladle, M., Bass, J. A. B. and Jenkins, W. R. 1972. Studies on Production and Food Consumption by the Larval Simuliidae (Diptera) of a Chalk Stream. Hydrobiologia 39:429-488

56 Speir, J. A. and Anderson, N. H. 1974. Use of Emergence Data for Estimating Annual Production of Aquatic Insects. Limnology and Oceanography 19:154-156.

57 McClure, R. G. and Stewart, K. W. 1976. Life Cycle and Production of the Mayfly Choroterpes (Neochoroterpes) Mexicanus Allen (Ephemeroptera: Leptophlebiidae). Annuals of the Entomological Society of America 69:134-144

58 Hudson, P. L. and Swanson, G. A. 1972. Production and Standing Crop of Hexagenia (Ephemeroptera) in a Large Reservoir. Studies in Natural Science, Natural Science Research Institute, Eastern New Mexico University. Volume 1, No. 4, 42 pp.

59 Horst, T. J. and Marzolf, G. R. 1975. Production Ecology of Burrowing Mayflies in a Kansas Resevoir. Verh. Internat. Verin. Limnol. 19:3029-3038

60 Pearson, W. D. and Kramer, R. H. 1972. Drift and Production of Two Aquatic Insects in a Mountain Stream. Ecological Monographs 24:365-385

61 Waters, T. F. 1966. Production Rate, Population Density and Drift of a Stream Invertebrate. Ecology 47:595-604

62 Zelinka, M. 1973. Die Eintagsfliegen (Ephemeroptera) in Forellenbachen der Beskiden. II. Produktion. Hydrobiologia 42:13-19

63 Tsuda, M. in Kazak, Z. and A. Hillbricht-Ilkowska (editors). 1972 Interim Results of the Yoshino River Productivity Survey, Especially on Benthic Animals. In Productivity Problems of Freshwaters. IBP, UNESCO, Polish Science Publ., Warsaw,

64 Waters, T. F. and Crawford, G. W. 1973. Annual Production of a Stream Mayfly Population: a Comparison of Methods. Limnology and Oceanography 18:286-296

65 Castro, L. B. 1975. Okologie und Produktionsbiologie von Agapetus fuscipes Curt. im Breitembach 1971-1972. Arch. Hydrobiol./Suppl. 45:305-375

66 Cushman, R. M., Elwood, J. W. and Hildebrand, S. G. 1975. Production Dynamics of Alloperla mediana Banks (Plecoptera: Chloroperlidae) and Diplectrona modesta Banks (Tricoptera: Hydropsychidae) in Walker Branch, Tennessee.Oakridge National Laboratory, Environmental Science Division Publication No. 785, 66 pages.

67 Decamps,H. and Lafont, M. 1974. Cycles Vivaux et Production des Micrasema Pyreneennes dans Mousses D'eau Cuorante (Tricoptera: Brachycentridae). Annls. Limnol. 10:1-32

68 Giani, N., and Laville, H. 1973. Biological Cycle and Production of Sialis lutaria L. (Megaloptera) in Port-Bielh Lake (Central Pyrennees). Annls. Limnol. 9:45-61

69 Yamamoto, G. in Kazak, Z. and Hillbricht-Ilkowska, A. (editors). 1972. Tropic Structure in Lake Tatsu-Numa, an Acidotropic Lake in Japan, with Special Reference to the Importance of the Terrestrial Community. In "Productivity Problems of Freshwaters"IBP, UNESCO, Polish Science Publication, Warsaw.

70 Andersson, E. 1969. Life cycle and Growth of Assellus aquaticus (L.) Rep. Inst. Freshwater Res. Drottningholm

49:5-26

71 Mann, K. H. in Edmondson, W. T. and Winberg, G. G. (editors). 1971. Use of the Allen Curve Method for Calculating Benthic Production. Pages 160-165 in A Manual on Methods for the Assessment of Secondary Productivity in Freshwaters.IBP Handbook No. 17, Blackwell Science Publication, Oxford and Edinburgh

72 Potter, D. W. B. and Learner, M. A. 1974. A Study of Benthic Macroinvertebrates of a Shallow Eutrophic Reservoir in South Wales with Emphasis on the Chironomidae (Diptera); their Life Histories and Production. Arch. Hydrobiol. 74:186-226

73 Beattie, M. et al. in Kazak, Z. and Hillbricht-Ilkowska, A. (editors) 1972. Limnological Studies on Tjeukemeer- a Typical Dutch "Polder Reservoir" pages 421-446 in Productivity Problems of Freshwaters. IBP, UNESCO, Polish Science Publication, Warsaw.

74 Tilley, L. J. 1968. The Structure and Dynamics of Cone Spring. Ecological Monographs 38:169-197

75 Mathias, J. A. 1971. Energy Flow and Secondary Production of the Amphipods Hyalella azteca and Crangonyx richmondensis occidentalis in Marion Lake, British Colombia. Journal of the Fisheries Research Board of Canada 28:711-726

76 Cooper, W. E. 1965. Dynamics and Production of a Natural Population of a Freshwater Amphipod, Hyalella azteca. Ecological Monographs 35:377-394

77 Eckblad, J. W. 1973. Population Studies of Three Aquatic Gastropods in an Intermittent Backwater. Hydrobiologia 41:199-219

78 Gillespie, D. M. 1969. Populations of Four Species of Molluscs in the Madison River, Yellowstone National Park. Limnology and Oceanography 14:101-114

79 Jonasson,P. M. 1972. Ecology and Production of the Profundal Benthos in Relation to Phytoplankton in Lake Esrom. Oikos (Suppl.) 14:1-148

80 Hunter, R. D. 1975. Growth, Fecundity and Bioenergetics in Three Populations of Lymnaea palustris in Upstate New York. Ecology 56:50-63

81 Learner, M. A. and Potter, D. W. B. 1974. Life History and Production of the Leech Helobdella stagnalis (L.) (Hirudinea) in a Shallow Eutrophic Reservoir in South Wales. Journal of Animal Ecology 43:199-208.

82 Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid Bioassessment Protocols for use in streams and rivers: Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency, EPA/444/4-89-001.

83 Washington, H. G. 1984. Diversity, Biotic and Similarity indicies, A review with special relevance to aquatic ecosystems. Water Research 6:653-694

84 Winget, R. N. and F. A. Mangum. 1979. Biotic condition index: integrated biological, physical and chemical stream parameters for management. USDA Forest Service, Intermountain Region, Ogden, UT, Contract No. 40-84M8-8524, 51 pages.

85 Weber, C. I. (editor). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. U.S. Environmental Protection Agency, EPA-670/4-73-001.

86 Lloyd, M., J. H. Zar, and J. R. Karr. 1968 On the calculation of information - theoretical measures of diversity. American Midland Naturalist 79:257-272.

87 Ludwig, J. A. and J. F. Reynolds. 1988. Statistical ecology - a primer on methods and computing John Wiley and Sons, New York. 329 pages.

88 Elliot, J. M. 1971 Some methods for the Statistical analysis of samples of benthic invertebrates Freshwater Biological Association, Scientific Publication No. 25

Taxonomic list and abundances of aquatic invertebrates collected 09/22/95 at station PERCHA-1, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae			P	11
Trichoptera	Hydropsychidae		Cheumatopsyche	L	11
Trichoptera	Hydropsychidae		Hydropsyche	L	54
Total: 3 taxa					75

Taxonomic list and abundances of aquatic invertebrates collected 09/22/95 at station PERCHA-3, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Trichoptera				P	11

Total: 1 taxa					11

Taxonomic list and abundances of aquatic invertebrates collected 09/22/95 at station PERCHA-4, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Odonata	Gomphidae			L	11

Total: 1 taxa					11

Taxonomic list and abundances of aquatic invertebrates collected 09/22/95 at station PERCHA-6, Percha Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Trichoptera	Hydropsychidae		Hydropsyche	L	1

Total: 1 taxa					1

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-1, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Crustacea					
Ostracoda				A	86
Class: Insecta					
Diptera	Chironomidae	Orthocladiinae		L	11
Diptera	Simuliidae			P	215
Diptera	Simuliidae		Simulium	L	4161
Diptera	Stratiomyidae		Euparyphus	L	11
Diptera	Stratiomyidae		Caloparyphus	L	22
Ephemeroptera	Baetidae		Baetis	L	22
Hemiptera	Naucoridae		Ambrysus	A	11
Lepidoptera				L	11
Trichoptera	Hydropsychidae		Hydropsyche	L	462

Total: 10 taxa					5011

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-2, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Chironomidae	Tanypodinae		L	11
Diptera	Simuliidae		Simulium	L	43
Diptera	Stratiomyidae		Caloparyphus	L	194
Hemiptera	Veliidae		Rhagovelia	L	32

Total: 4 taxa					280

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-3, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Crustacea					
Ostracoda				A	22
Class: Insecta					
Coleoptera	Dryopidae		Helichus	A	183
Coleoptera	Elmidae		Stenelmis	L	54
Coleoptera	Elmidae		Stenelmis	A	11
Diptera	Chironomidae			P	97
Diptera	Chironomidae	Chironominae		L	161
Diptera	Chironomidae	Orthocladiinae		L	366
Diptera	Chironomidae	Tanypodinae		L	75
Diptera	Empididae		Clinocera	L	11
Diptera	Simuliidae			P	22
Diptera	Simuliidae		Simulium	L	183
Diptera	Stratiomyidae		Euparyphus	L	22
Diptera	Stratiomyidae		Caloparyphus	L	1269
Diptera	Tabanidae		Tabanus	L	11
Ephemeroptera	Baetidae		Baetis	L	32
Hemiptera	Naucoridae		Ambrysus	A	97
Lepidoptera	Pyralidae		Petrophila	L	11
Odonata	Calopterygidae		Hetaerina	L	183
Odonata	Coenagrionidae		Argia	L	86
Odonata	Gomphidae			L	11
Trichoptera	Hydropsychidae		Cheumatopsyche	L	32
Trichoptera	Hydropsychidae		Hydropsyche	L	280
Trichoptera	Philopotamidae		Dolophilodes	L	11

Total: 22 taxa					3226

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-4, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dryopidae		Helichus	A	11
Diptera	Chironomidae	Chironominae		L	11
Diptera	Chironomidae	Orthocladiinae		L	11
Diptera	Chironomidae	Tanypodinae		L	11
Diptera	Stratiomyidae		Euparyphus	L	32
Diptera	Stratiomyidae		Caloparyphus	L	247
Diptera	Tabanidae		Tabanus	L	11
Ephemeroptera	Baetidae		Baetis	L	22
Hemiptera	Naucoridae		Ambrysus	A	22
Lepidoptera	Pyralidae		Petrophila	L	97
Odonata	Aeshnidae			L	32
Odonata	Calopterygidae			L	11
Odonata	Coenagrionidae			L	11
Odonata	Gomphidae			L	11
Trichoptera	Hydroptilidae			P	11
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae		Physella	A	11

Total: 16 taxa					559

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-5, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Arachnoidea					
Hydracarina				A	22
Class: Crustacea					
Ostracoda				A	129
Class: Insecta					
Coleoptera	Curculionidae			A	11
Coleoptera	Haliplidae		Peltodytes	A	11
Diptera	Chironomidae			P	22
Diptera	Chironomidae	Chironominae		L	65
Diptera	Chironomidae	Orthocladiinae		L	43
Diptera	Chironomidae	Tanypodinae		L	65
Diptera	Simuliidae		Simulium	L	75
Diptera	Stratiomyidae		Euparyphus	L	11
Diptera	Stratiomyidae		Caloparyphus	L	22
Ephemeroptera	Baetidae		Baetis	L	43
Ephemeroptera	Tricorythidae		Tricorythodes	L	65
Hemiptera	Naucoridae		Ambrysus	A	11
Lepidoptera				L	43
Odonata	Calopterygidae		Hetaerina	L	11
Odonata	Coenagrionidae			L	11

Total: 17 taxa					656

Taxonomic list and abundances of aquatic invertebrates collected 10/07/95 at station TIERRA-6, Tierra Blanca Creek, New Mexico. Life stage: L = Larve, P = pupae, A = adult. NC = not calculated, abundance data is number/m^2 for quantitative samples and number per sample for qualitative samples.

Order	Family	Subfamily	Genus/species	Life Stage	sample abundance
Phylum: Arthropoda					
Class: Insecta					
Diptera	Stratiomyidae		Caloparyphus	L	22

Total: 1 taxa					22